MARCH 1954

Journal

VOL. 46 • NO. 3

AMERICAN WATER WORKS ASSOCIATION

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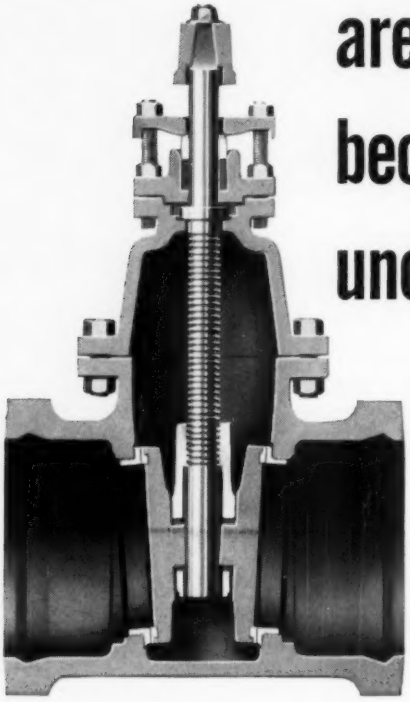

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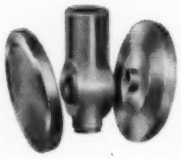

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Journal

AMERICAN WATER WORKS ASSOCIATION

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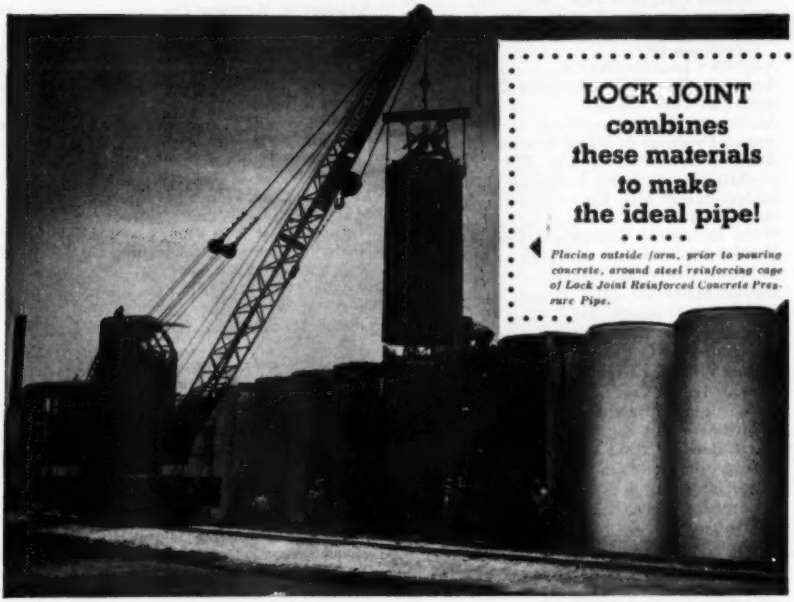

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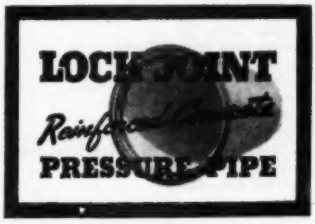

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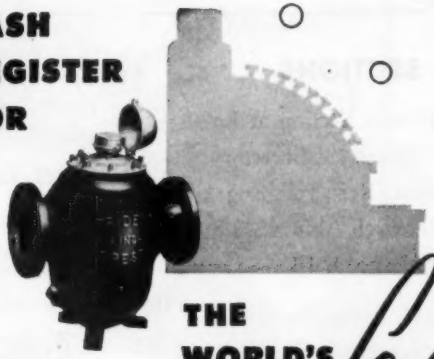

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Coming Meetings

AWWA SECTIONS

Mar. 17–19—Illinois Section at La-Salle Hotel, Chicago. Secretary, Dewey W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 122 S. Michigan Ave., Chicago 3, Ill.

Mar. 18—New England Section at Hotel Statler, Boston. Secretary, George G. Bogren, Partner, Weston & Sampson, 14 Beacon St., Boston 8, Mass.

Mar. 29–31—Southeastern Section at Poinsette Hotel, Greenville, S.C. Secretary, N. M. deJarnette, 245 State Office Bldg., Atlanta 3, Ga.

Apr. 7–9—Kansas Section at Broadview Hotel, Emporia. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud, Salina, Kan.

Apr. 9—California Section at San Carlos Hotel, Monterey. Secretary, H. F. Jerauld, Supt. of Stores & Equipment, Water Dept., 1040 Manzanita Ave., Pasadena 3.

Apr. 12–14—Canadian Section at Royal York Hotel, Toronto. Secretary, A. E. Berry, Director, Ontario Dept. of Health, Parliament Bldgs., Toronto 8, Ont.

Apr. 22–23—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary, E. Bruce Meier, Asst. Prof. of Civil Engineering, Univ. of Nebraska, Lincoln, Neb.

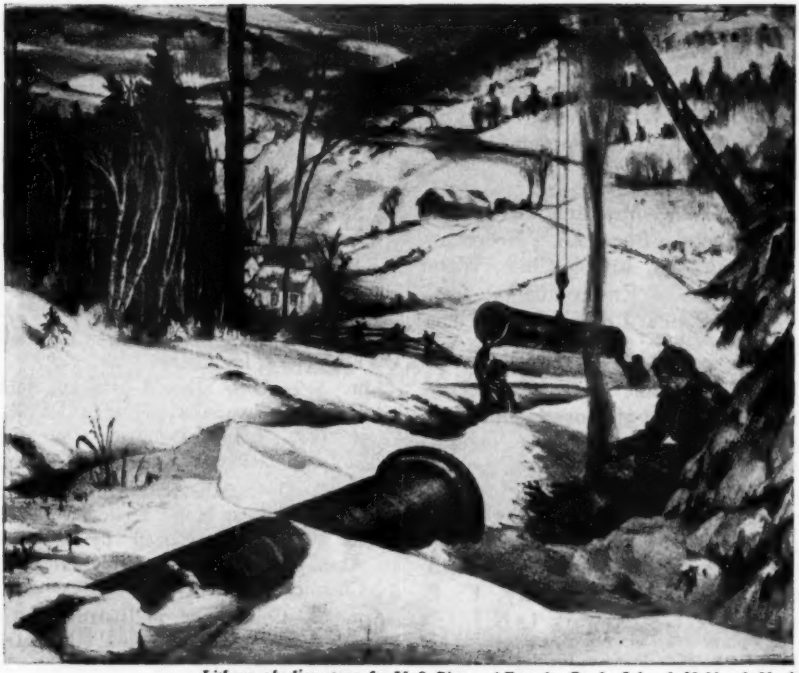
Apr. 22–23—New York Section at Woodruff Hotel, Watertown. Secretary, Kimball Blanchard, Rm. 1922, 50 W. 50 St., New York 20, N.Y.

AWWA ANNUAL CONFERENCE

Seattle, Wash. **May 23-28, 1954**

All reservations are being cleared through the AWWA office. The hotels have agreed to accept no reservations for the 1954 Conference except as they are requested on the standard form, through the AWWA.

(Continued on page 8)



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Coming Meetings

(Continued from page 6)

Apr. 22–24—Arizona Section in Tucson. Secretary, M. V. Ellis, Supervisor, Sewage Treatment Plant, Phoenix, Ariz.

Apr. 23–24—Montana Section at Baxter Hotel, Bozeman. Secretary, A. W. Clarkson, Acting Chief, Water Section, Div. of Environmental Sanitation, State Board of Health, Helena, Mont.

May 25—Pacific Northwest Section luncheon meeting at Norselander Cafe, Seattle, Wash. (Business meeting only; to be held during AWWA Conference May 23–28.)

Jun. 22—New Jersey Section Summer Outing (inspection trip and luncheon) at Boonton. Secretary, C. B. Tygert, Box 178, Newark 1, N.J.

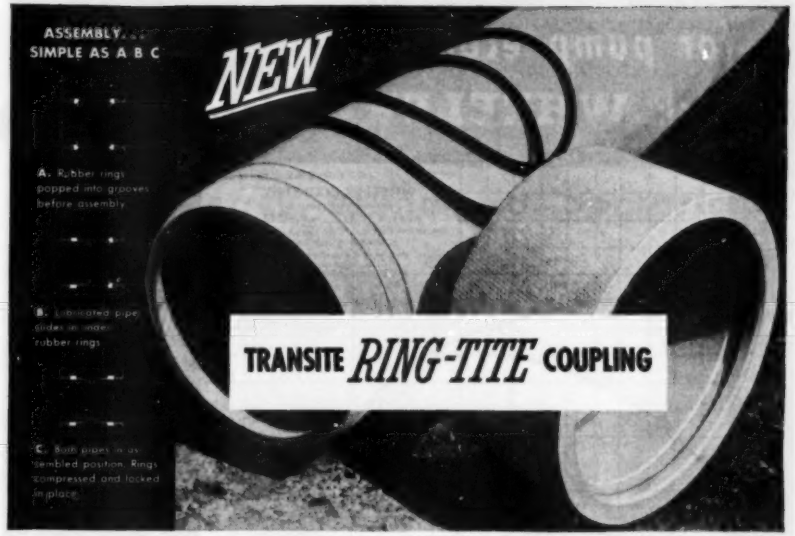
Jun. 23–25—Pennsylvania Section at Americus Hotel, Allentown. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg, Pa.

FALL SECTION MEETINGS

Sept. 9–10—New York, in Montauk, L.I.
Sept. 15–17—Michigan, in Muskegon
Sept. 20–22—Kentucky-Tennessee, in Nashville
Sept. 22–24—Ohio, in Dayton
Sept. 26–28—Missouri, in Jefferson City
Sept. 28–30—Wisconsin, in Green Bay
Oct. 6–8—Minnesota, in St. Paul
Oct. 13–15—Iowa, in Cedar Rapids
Oct. 17–20—Southwest, in El Paso, Tex.
Oct. 24–27—Alabama-Mississippi, in Birmingham
Oct. 26–29—California, in Long Beach
Oct. 27–29—Chesapeake, in Baltimore
Nov. 3–5—Virginia, in Richmond
Nov. 4–6—New Jersey, in Atlantic City
Nov. 7–10—Florida, in St. Petersburg
Nov. 8–9—West Virginia, in Huntington
Nov. 8–10—North Carolina
Nov. 9–10—Rocky Mountain, in Colorado Springs

OTHER ORGANIZATIONS

Mar. 10–12—Short Course for Water and Sewerage Personnel, at Louisiana State Univ., Baton Rouge. Details from John H. O'Neill, Director, Div. of Public Health Eng., Dept. of Health, Civil Courts Bldg., New Orleans 7, La.
Mar. 15–19—National Assn. of Corrosion Engineers, in Kansas City, Mo.
Apr. 6–9—U.S.–Mexico Border Public Health Assn., in Albuquerque, N.M.
Apr. 6–7—Industry–Faculty Conference at Louisiana State Univ., Baton Rouge
Apr. 21–23—Southern Industrial Wastes Conference, at Hotel Shamrock, Houston, Tex. Sponsored by Southern Assn. of Science & Industry and Texas Chemical Council.
Apr. 22—Conference on Instrumentation in Water, Sewage, and Industrial Waste Treatment, at Manhattan College, N.Y.
May 4–6—American Public Power Assn., in Chicago
May 4–7—American Welding Society, in Buffalo, N.Y.
Jun. 13–18—American Society for Testing Materials, in Chicago
Jul. 25–31—Inter-American Conference of Sanitary Engineering, in Sao Paulo, Brazil.
Oct. 4–6—New England Water Works Assn., Poland Springs, Me.
Oct. 11–14—Federation of Sewage & Industrial Wastes Assn., in Cincinnati.
Oct. 11–15—American Public Health Assn., in Buffalo
Oct. 17–20—American Society of Civil Engineers, in New York City
Oct. 19–22—Pennsylvania Water Works Assn., in Atlantic City, N.J.
Nov. 17–19—Water Works Management Short Course, at Univ. of Illinois. Allerton Park, Ill.
Nov. 28–Dec. 3—American Society of Mechanical Engineers, in New York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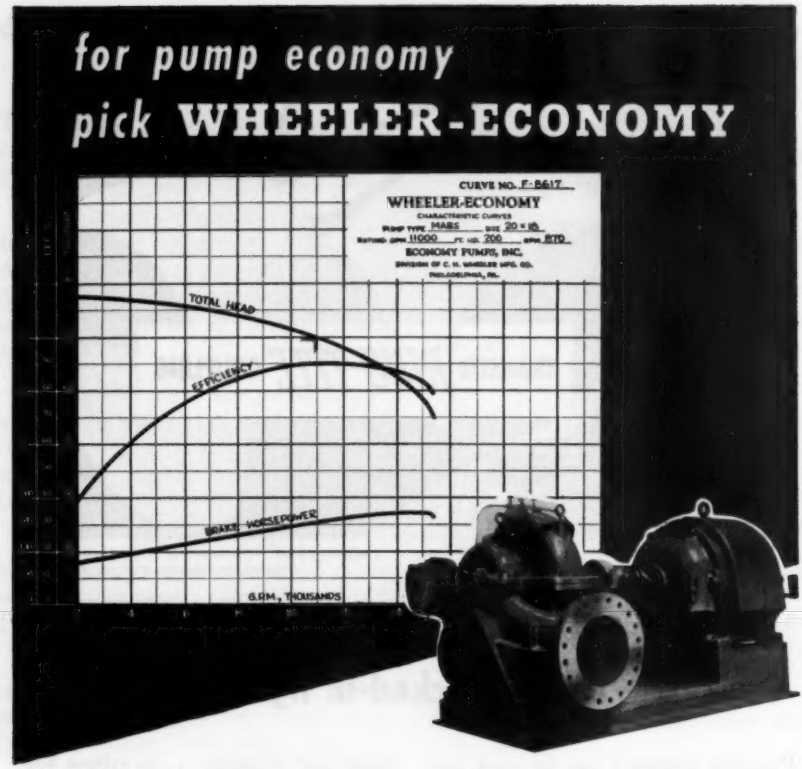

The Type M pump shown here is typical of Wheeler-Economy pumps for water works service. Its design embodies heavily ribbed cases and high pressure flange specifications where required. Single or dual volutes are available. Sleeve bearings (oil lubricated) or ball bearings (either oil or grease lubricated) may be furnished in most water works sizes. The pump shown has oil lubricated ball bearings.

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WE-401

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The Cochrane Hydromatic Single Control Valve provides positive, accurate control of all phases of the softening and regenerating cycle.

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Cochrane's 91 years of water conditioning leadership and its complete line of equipment assures you unbiased recommendations for equipment to performance requirements. For the right answer to your water problem, call a Cochrane Engineer today.

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3124 N. 17th STREET, PHILADELPHIA 32, PA.

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Please send me a copy of your Publication 4520-A on your Zeolite Softeners with the Cochrane Hydromatic Single Control Valve.

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MAXIMUM Water Conservation at MINIMUM Cost!

Industrial Reservoir—West Texas

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SUBSTANTIAL savings, proven dependability and significantly reduced maintenance problems are provided by the newest, *fully-proven* material specifically designed for elimination of seepage and erosion in reservoirs.

GULF-SEAL Exposed Prefabricated Asphalt Linings were thoroughly tested by nationally-known laboratories, major oil companies, large industrial concerns, both in the laboratory and by actual installations which later were subjected to seepage tests. At present, more than a million and a quarter square feet are in use. The dependability, durability and longevity of GULF-SEAL linings are established beyond question.

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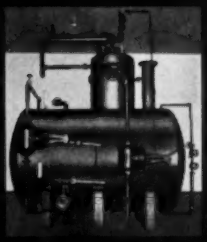
There's no dodging the question today. High costs and low budgets demand straight answers. The installation of water conditioning equipment is an important step that merits the careful consideration of every factor involved. Modern General Filter water conditioning installations are designed with a practical eye on original equipment and installation costs. Equally important, however, is the extent of continuing service available from the company with which you are dealing. General Filter's staff of highly trained engineers and chemists are at your call on a moment's notice. General Filter's 40 branches are located across the country to give you prompt dependable service. Make your own comparisons and you will join the hundreds of General Filter water treatment plants that are enjoying lower first cost — lower operating costs — lower maintenance costs.



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FOR 100 YEARS

Photo:
Ewing Galloway

This is Chicago, second largest city in the U. S. A.—population over 3½ million.

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A view of Lake Street, Chicago, as it looked 100 years ago.

MODERNIZED **cast iron**

they've been coming back for more...

CHICAGO installed cast iron water mains 100 years ago... and installs them today!

Chicago's skyline has changed magically in a century but the underground lines that transport water are still cast iron. Nearly 100% of her water distribution system consists of cast iron pipe. This city of "magnificent distances" has over 4,000 miles (21 million feet) of cast iron mains, supplying more than one billion gallons of water per day to a population approaching four million.

Section of a century-old cast iron main still serving in Chicago's vast water distribution system.

A famous jurist defined *good will* as the "probability of the customer's returning to the old stand." Chicago's Water Department has been coming back for more cast iron pipe for 100 years. That's good will—yes—built on proved performance. Chicago has century-old cast iron pipe in its water distribution system.

Cast iron pipe has been a rugged, long-lived product from the earliest days. Today's *modernized* cast iron pipe, centrifugally cast, is even stronger, tougher, and more uniform in quality. And, where needed and specified, it is centrifugally lined with cement mortar to assure sustained carrying capacity throughout the long life of the pipe.

Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Ave., Chicago 3.

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The Q-Check stenciled on pipe is the Registered Service Mark of the Cast Iron Pipe Research Association.

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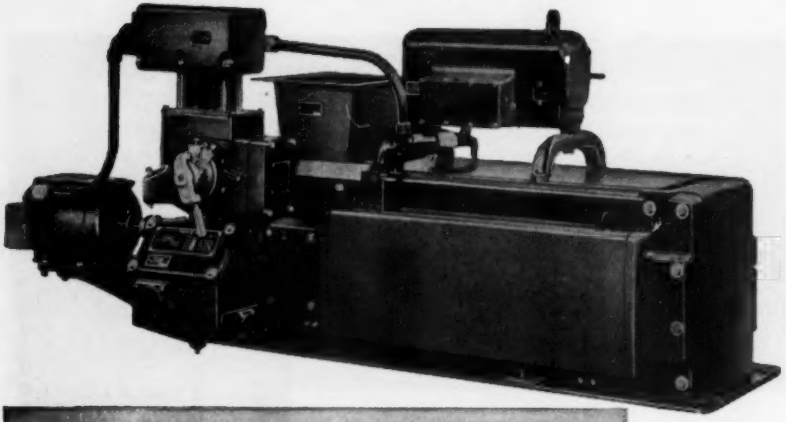
W&T Merchen Feeders give precision feeding of any waterworks chemical...*by weight.*



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—Remote feed rate adjustment if desired.

—Adaptable to fully automatic proportional control.

Hundreds of installations feeding waterworks chemicals, industrial chemicals and feed and flour ingredients have proved the accuracy and dependability of these belt-type gravimetric feeders.

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Rugged Concrete Pipe Withstands the Severe Stresses of Jacking Operations

The photo shows 84-in. concrete pipe being jacked under several railroad tracks to provide protection for a 48-in. water main of the Metropolitan Utilities District in Omaha. The only interference with normal traffic was the observation of a "slow order."

This is another example of how sturdy concrete pipe meets almost any combination of site or soil conditions or drainage requirements. Concrete pipe also resists heavy traffic impact, high fill loads and severe climate.

Jacking concrete pipe minimizes roadbed disturbances under roads, streets and railroads. This saves money by reducing or eliminating costly maintenance often caused by trench fill settlement.

Besides great strength and easy installation concrete pipe offers:
1. MAXIMUM HYDRAULIC CAPACITY—assured by smooth interior walls, clean, even joints and freedom from damaging internal corrosion.
2. EXTRA LONG LIFE—proved by long years of dependable service in thousands of installations.
3. LOW-ANNUAL-COST ECONOMY—resulting from its moderate first cost, long years of service and little or no maintenance expense.

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M H

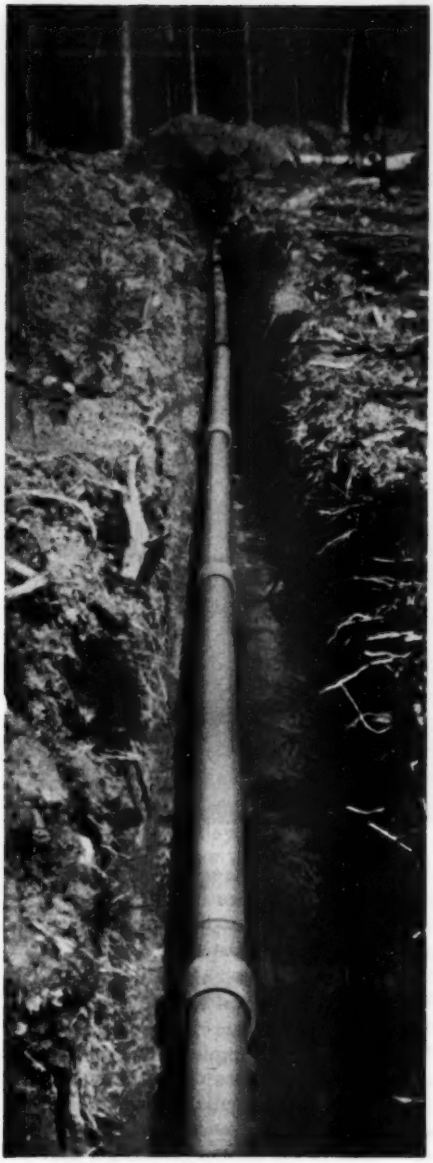
MOTOR OPERATED GATE VALVES

Electric motor operation is recommended for large M & H Gate Valves, or where valves are frequently operated, or where valves are located in remote, inaccessible or hazardous places. The remote control, possible with electric motor operated M & H Valves, is a convenience which frequently increases efficiency and reduces operating costs.

The 36" motor operated M & H Valve illustrated here is standard M & H Gate Valve design and construction—iron body, bronze mounted, double disc, parallel seat. All sizes of electric motor operated M & H Gate Valves are available in Class A for 50 lbs. working pressure, Class B for 100 lbs. working pressure or A.W.W.A. Class C for 150 lbs. working pressure. Furnished with hub, flanged or mechanical joint ends.

M & H Gate Valves may be ordered equipped also with usual accessories such as gearing, by-passes; rollers, tracks and scrapers; double square bottom, indicators, or for hydraulic cylinder operation. For complete information, write or wire M & H Valve and Fittings Company, Anniston, Alabama.

M&H PRODUCTS FOR WATER WORKS • FILTER PLANTS INDUSTRY • SEWAGE DISPOSAL AND FIRE PROTECTION



Century.

ASBESTOS-CEMENT PIPE installed in Penna. State Park

Hickory Run State Park in White Haven is one of several Pennsylvania Parks in which "Century" pipe has been used to supply water for recreational areas. For generations to come, this line will carry its full capacity, without the need for maintenance.

Long, trouble-free service is to be expected of "Century" pipe. Being non-metallic, this exceptionally strong, durable pipe cannot tuberculate, rust, or corrode. Its bore stays smooth and frictionless, keeping pumping costs low. It is light in weight, easy to lay, low in cost.

Before you decide on the pipe for *any* water-carrying line, for economy's sake you ought to find out all about "Century" pipe. Write for "Mains Without Maintenance"—an informative free booklet of real value to anyone concerned with water main construction.

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Nature made Asbestos... Keasbey & Mattison has made it serve mankind since 1873

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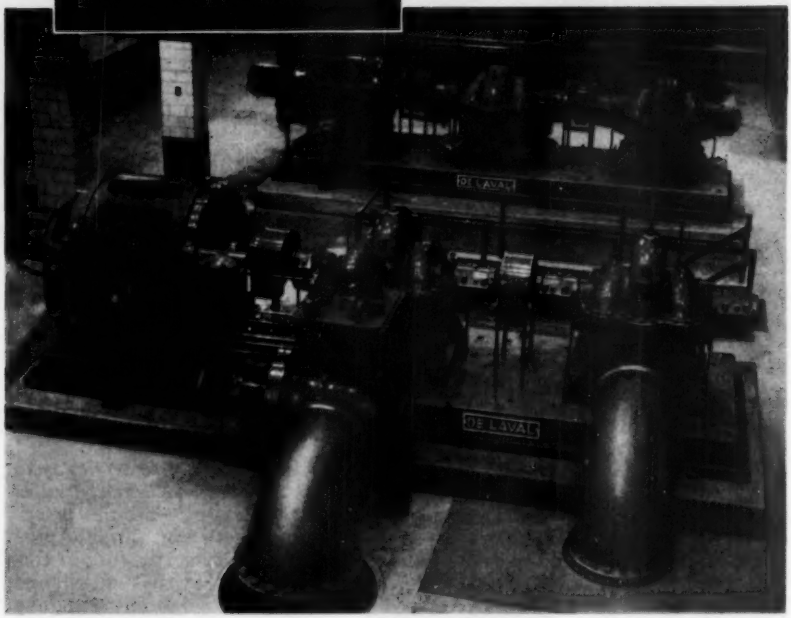
DE LAVAL
CENTRIFUGAL PUMPS

bring 68% water reserve to Allentown, Pa.



These 15 mgd, 288 foot-head centrifugal pumps are among the total of nine De Laval units that provide a new, all-time high in water availability at Allentown, Pa. Full capacity is 42 mgd, present consumption 25 mgd—a "cushion" of 68% against the heavier demands of future years.

Part of the problem in setting up this big, new facility was to utilize as much equipment as possible from the old plant. Here, De Laval versatility paid off, for several units which had already been in use for twenty years tied in easily, economically, with the new system.

More than 80% of America's cities look to De Laval for the utmost in pump performance and dependability. And they profit daily from De Laval's 53 years of experience in municipal water works pumping. De Laval units range from 100 thousand to 100 million gallons per day.

DE LAVAL *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY
822 Nottingham Way, Trenton 2, New Jersey

Valves Installed in 1907 Never Out for Repairs

VALVE SERVICE RATINGS

SUITABILITY: Couldn't be better

FEATURES: Non-jamming double disc

MAINTENANCE COST: Almost nil

SERVICE LIFE: 46 yrs. – Still O.K.

OPERATING RESULT: Economical, trouble-free service

AVAILABILITY: Regular item – Current No. 2485

In the Brackenridge Borough, Pa., municipal water plant, having forty large Crane iron body double disc gate valves on services up to 90 pounds pressure.

THE CASE HISTORY

How wisely Brackenridge Borough water utilities engineers chose valves in 1907 is self-evident. Today, 46 years later, the forty original Crane valves installed are still on the job—still giving completely satisfactory service. What's more, except for occasional repacking, none of the valves have needed repairs of any kind. And indications are, many years of service remain in the valves.

Valves that set performance records like this aren't bought on price alone—it's assurance of quality that counts in buying. That's thrifty buying—the only way to get best value.

THE VALVE

Highly developed for extra durability and dependability, today's Crane A. W. W. A. valves help water utilities operate efficiently now and in the future. Available in flanged or hub ends up to 36-in. size, these valves permit complete standardization. See your Crane Catalog.

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TYPICAL TOWN

saving money with

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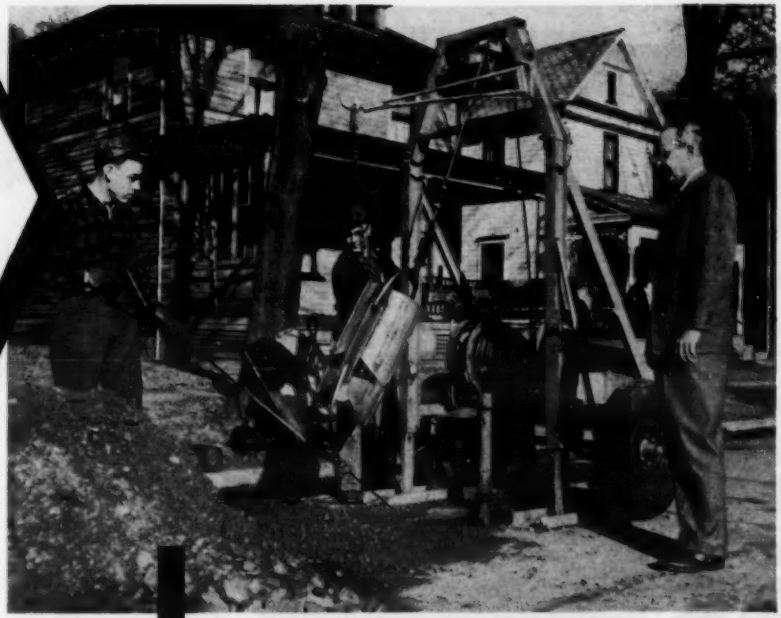

Franklin, Pennsylvania, is one of many typical American towns that use "Flexible" sewer-cleaning equipment. Shown is a Model 23R6 "Flexible" Power Bucket Machine – the pile of dirt representing "part of one day's work!" Wm. May, in charge of sewer maintenance, is operating the machine . . . while Mayor-Flect R. R. Bleakley, presently Chairman of the Streets and Sewer Committee, watches the operation. Mr. Bleakley, together with Mr. J. McKee Snow, City Engineer, was largely instrumental in choosing "Flexibles," after careful tests. The need for "Flexibles" was so great that two shifts are being used to clean the city's sewers. Here is a city that is so greatly pleased with the results they recommend "Flexible" equipment highly.

Write for our **FREE** *Catalog*

Flexible **SALES CORPORATION**

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MUELLER

TAPPING SLEEVES AND VALVES

are your **STRONGEST** *branch main connections!*

Any movement of a branch main creates high stresses at the branch main connection. Mueller tapping connections are specifically designed with heavy ribs to actually strengthen the main. Connections may be made quickly, under pressure, without loss of water or interruption of flow

The heavy, corrosion-resistant bolts have self-holding heads and are closely and evenly spaced in perfect alignment along the side flanges of the sleeve for maximum rigidity. The wide, thick side flanges are grooved for positive retention of the lead gaskets to assure a lifetime watertight joint.

A simple flanged connection between the tapping sleeve and tapping valve assures positive alignment for accurate drilling and ease of installation

Mueller Mechanical Joint Sleeves can be adapted to fit all classes of cast iron pipe by changing the end gaskets. The raised cast ring in the calked joint sleeves centers the ring and keeps the use of expensive lead to a minimum.

Mueller Tapping Valves have oversize seat openings to allow the use of full-size shell cutters.

Tapping valves can be furnished with either "O" ring packing or conventional packing and mechanical joint or hub end outlet.

Consult your Mueller Water Works Catalog W-96 or see your Mueller representative for full details.

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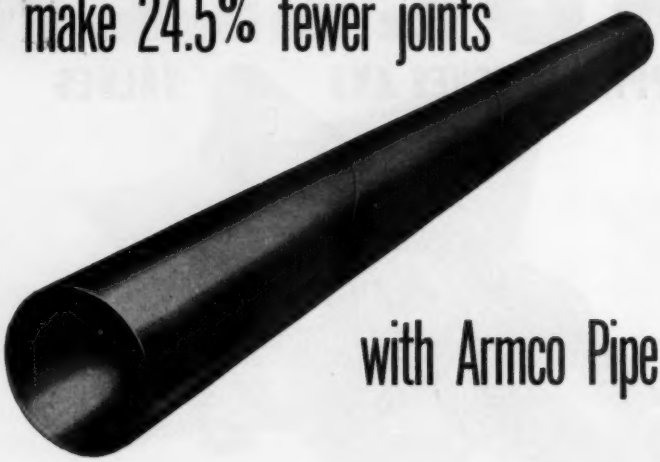
Dependable Since 1857

MAIN OFFICE & FACTORY DECATUR, ILLINOIS

make 24.5% fewer joints



with Armco Pipe

If you are using regular 40-foot pipe lengths, 132 joints will be required each mile. But by changing to 50-foot lengths of Armco Welded Steel Pipe, you need only 106 joints for the same distance. Thus, you can eliminate 26 joints—or almost one out of every five.

Besides cutting installation costs, the longer lengths of Armco Pipe also simplify hauling and handling.

With Armco Pipe it is easy to meet strength and capacity needs for your supply line, force main or water works piping. Diameters range from 6 to 36 inches; wall thicknesses are from 9/64- to 1/2-inch.

Outside coatings are supplied to A.W.W.A. specifications, and a spun enamel lining will prevent tuberculation. Write us for more data. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Div., 2364 Curtis St., Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.

ARMCO WELDED STEEL PIPE

ARMCO

Meets A. W. W. A. Steel Water Pipe Specifications

CALMET

WILL GIVE YOU MAXIMUM REVENUE from every customer, and full frost protection, with a minimum cost of upkeep.

The Meter You Can COUNT On!

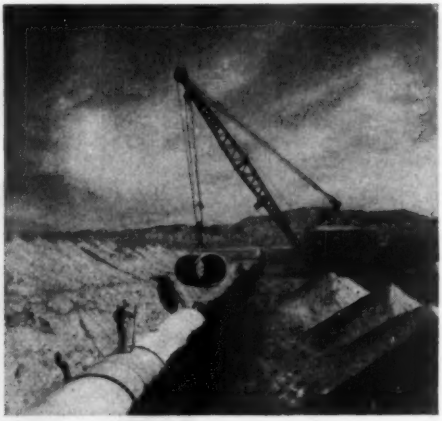
Manufactured by

Well Machinery & Supply Co., Inc.

Fort Worth, Texas

U. S. BUREAU OF RECLAMATION SPECIFIES

Concrete Pressure Pipe



When the U.S. Bureau of Reclamation builds a pipeline, it must last a long, long time.

This is why the Bureau has specified concrete pressure pipe in many projects under its jurisdiction throughout the Western States. In the State of California alone, approximately 3,000,000 feet of concrete pressure pipe have been used in diameters ranging from 12″ through 84″, and for heads up to 650 feet. These jobs include the Coachella Valley Project, the Cachuma Project near Santa Barbara, both barrels of the San Diego Aqueduct, and the Central Valley Project.

Large pipe distribution systems, often calling for heads of 200 feet and over, are jobs for concrete pressure pipe. So, when your city is planning a water transmission system with either low or high heads be sure to get the facts on concrete pressure pipe.

Member companies manufacture concrete pressure pipe in accordance with nationally recognized specifications

Concrete PRESSURE Pipe

WATER FOR GENERATIONS TO COME

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION
228 North LaSalle Street
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No, we're not miracle men, but we can guarantee that regardless of the inside condition of your water main, we can restore their original rated capacity to 95% or better.

Think of the increased volume, higher pressure and lower pumping costs that National cleaning will bring to your system—then write or call National today.

There's absolutely no obligation to have National's experienced engineers call.

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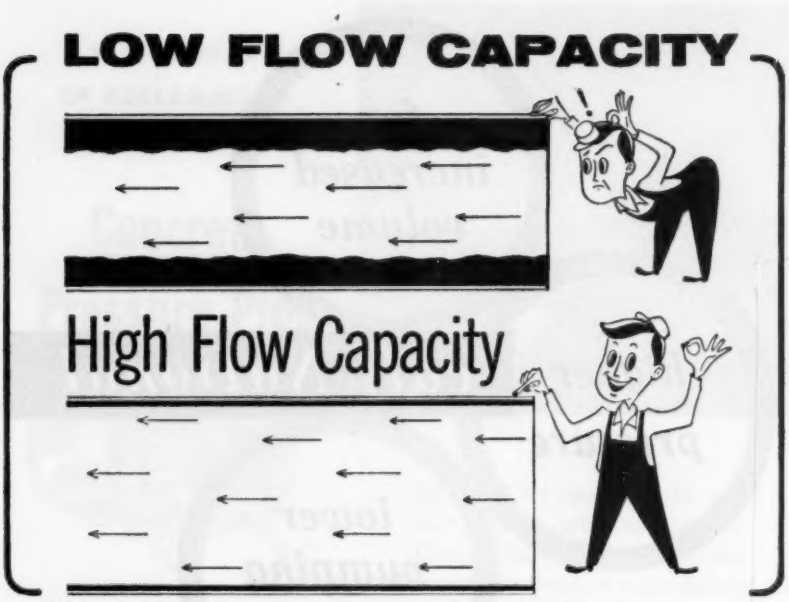

. . . Bitumastic 70-B Enamel makes the difference by preventing corrosion

● Flow capacity *stays* high when Bitumastic® 70-B Enamel protects interior surfaces of steel pipe lines. This durable enamel prevents rust, corrosion, incrustation and tuberculation... keeps pipe lines from "shrinking." With this kind of protection, there's no need to spend money on *over-sized* pipe in order to allow for future loss in flow capacity. Flow tests conducted on steel pipe lines, centrifugally lined with hot Bitumastic 70-B Enamel, have shown the value of Hazen-Williams coefficient "C"=145 to 160.

BITUMASTIC 100th Anniversary PROTECTION 1854 1954

You can save money in another way with Bitumastic 70-B Enamel. When applied to a thickness of 3/32", it protects the exterior of pipe against the corrosive action of the soil. It is wasteful to specify an excess of wall thickness to compensate for corrosion. It is more economical to specify just enough wall thickness to give the pipe adequate structural strength and to use Bitumastic 70-B Enamel to prevent corrosion.

Use strong, durable steel pipe, lined and coated with Bitumastic 70-B Enamel, and give your community worthwhile savings. Write for full information on protecting large-diameter water lines.

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KOPPERS COMPANY, INC.

Tar Products Division, Dept. 305T, Pittsburgh 19, Pennsylvania

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It's a typical American success story—this history that spans nearly three quarters of a century and started with a one man muscle power drilling rig—and an idea.

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Water Wells
Vertical Turbine Pumps
Water Treatment

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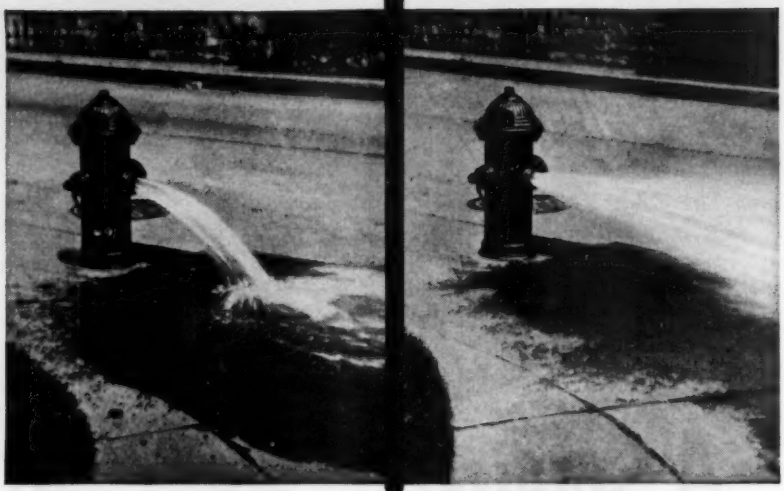

by CENTRILINE

Low water pressure due to friction loss can be permanently corrected by Centrilining. Properly applied cement-mortar linings in pipelines eliminate interior tuberculation and corrosion forever.
The continuous rigid surface also prevents leakage from joints or holes in the pipe wall.
And it's all done with the pipes in place. The result is the equivalent of a new pipeline at a fraction of the cost of new pipe.

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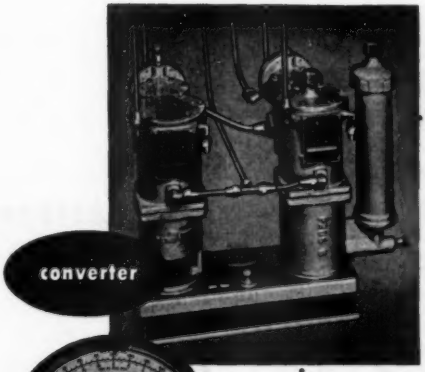
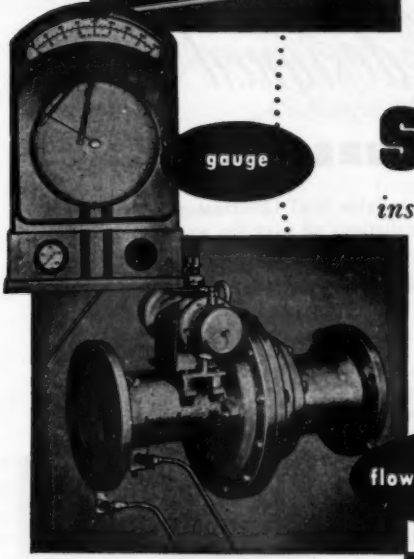


C.-A.-P.

Controlled Air Pressure

SYSTEM

instant, accurate measurement of head and flow... plus automatic flow control!



Your operation is only as efficient as your measurement and control methods. The C.-A.-P. System provides an accurate measure of head loss and flow and an instantaneous, automatic adjustment of flow rate. Controlled Air Pressure eliminates inaccuracies of stuffing boxes and complex equipment of diaphragm or mercury operated gauges.

See For Yourself...

get this detailed C.-A.-P. bulletin complete with drawings. Ask for Bulletin 1100-J.

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Plants in Chicago & Joliet, Illinois

FIELD ENGINEERING OFFICES IN 26 PRINCIPAL CITIES

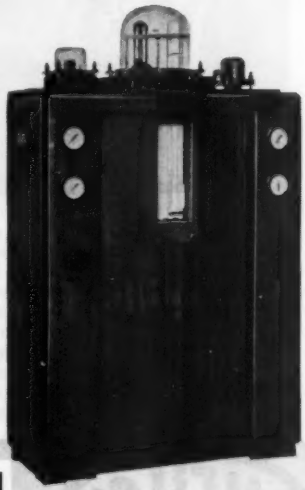
Carefully designed

. . . BY NATURE

Carefully designed, too, are the dependable W&T Chlorinators which are familiar sights in thousands of installations all over the world.

For example — the W&T Visible Vacuum Principle which, by means of a glass bell jar, permits simple, visual checks on proper chlorinator performance.

And, for another — the inherent safety and economy of W&T Chlorinators, which are available with controls and accessory equipment to meet exactly each specific chlorination problem.



Behind these and many other design features is a nation-wide field organization, which, by "nature," is resourceful and technically skilled. The services of this organization are designed to give you — in the most efficient manner possible — the practical and proved results of a continuing quest for the best in chlorination equipment.

If, by nature, you're skeptical, you can easily prove it to yourself by passing along your own particular chlorinator problem. You'll hear from us promptly — and without obligation, of course.

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WALLACE & TIERNAN

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Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 46 • MARCH 1954 • NO. 3

Determination of Water Rate Schedules

Committee Report

A report of Committee A4.B—Water Rates, presented on May 12, 1953, at the Annual Conference, Grand Rapids, Mich., by Louis E. Ayres (Chairman), Civ. Engr., Ayres, Lewis, Norris & May, Ann Arbor, Mich. The other committee members were: T. L. Amiss, C. H. Capen, R. H. Ellis, D. L. Erickson, M. P. Hatcher, N. B. Jacobs, W. A. Kunigk, A. P. Learned, I. P. Macnab, H. F. Smith, S. K. Velliquette, Paul Weir, and W. V. Weir. Representing NEWWA were: P. A. Shaw, W. A. Gentner, and E. T. McDowell.

THE subject of water rates has been involved in controversy for several decades, and it is not possible to resolve this controversy now by any simple set of rules. Not only are divergent views concerned but differences in local conditions, laws, ownership (public or private), control (commission or local), and other matters must also be considered. As many of the issues have already been reviewed by the committee in recent JOURNALS (*1–4*), only those aspects which have a bearing on committee recommendations are included in the text of this report.

In view of the circumstances, the report is aimed at outlining the basic elements involved in water rates and suggesting *alternate* rules of procedure for formulating rates, thus permitting the exercise of judgment and preference to meet local conditions and requirements.

The subject matter is presented in four sections:

Section 1—Amount of Revenue: Amount of revenue may be determined by either of two methods of approach: the utility basis and the cash basis. The applicability of each basis is discussed, and illustrative applications are presented showing the possible range in total revenue, depending on the basis used and the assumptions adopted.

It is suggested that the income from rates in suburban areas should be determined on the utility basis.

Section 2—Classification of Costs: Costs are considered on *two* bases: the common basis required by the *demand*

theory of rates, which allocates expense to capacity or demand, output, and customer costs; and the *functional* classification of costs into production, distribution, customers' service, fire, and special costs. Modified rules are suggested for the classifications under the demand basis, and an illustrative application of the functional distribution of costs is presented.

Section 3—Allocation of Expense: Allocation of expense between water users and taxpayers, and between the several classes of normal and special users, is considered. The wide range of opinion on the portion of the water works burden that should be assessed to property is noted, and practicable limits are suggested for the income to be derived from taxes, assessments, or other levies on property.

Fire protection is treated as a special use, and an attempt is made to suggest methods for the computation and collection of reasonable fire charges without recourse to an unacceptable increase in the tax burden.

Sprinkling, air conditioning and refrigeration, and other special demands that increase the peak load are in some areas placing an increased burden on water systems. To control such demands and to distribute the additional costs more equitably, demand charges are suggested and illustrated.

Section 4—Rate Schedules for Normal Users: An attempt is made to present definite rules for the formulation of rates which will distribute normal expense among *all* customers, as nearly as possible in proportion to the cost of supplying the commodity. Special users whose intermittent demands require excess plant would pay these normal rates for all water used, plus additional demand charges as suggested in Section 3.

Methods or rules for determining rate schedules are developed on two bases: the demand (or capacity) basis and the functional (or customer cost) basis. Both of these bases have been used for many years, but their applications have been the cause of much of the controversy in rate making. The demand basis was outlined in the *Manual of Water Works Practice* (*5*) in 1925, and the functional or customer cost basis generally follows a committee report (*6*) adopted by AWWA on May 24, 1923. The principal difference between the two bases involves the amount of the service charge—whether it should include a substantial portion of demand or ready-to-serve costs, or be limited to customer costs only. Rules are proposed herein that may help to reconcile the two bases and permit the use of either theory, with comparable results.

Section 1—Amount of Revenue

Every water works should receive a gross revenue in an amount that will suffice to provide adequate service and assure the maintenance, development, and perpetuation of the system.

Two bases for the determination of revenue have been used widely, and each has its particular field of application. They may be called the "utility" basis and the "cash" or budget basis (*3, 7*).

Utility Basis

The utility basis is required for all privately owned water works and for the relatively few publicly owned systems under the control of state commissions or other outside regulatory

authorities. State commissions exercise jurisdiction over municipally owned water works in the regulation of rates within corporate limits in six states: Maine, Montana, Nevada, West Virginia, Wisconsin, and Wyoming (*8*).

The utility basis requires the determination of a rate base, or the amount of capital upon which the utility is entitled to earn a return, and the fixing of a fair rate of return on the rate base.

The gross revenue, on this basis, would therefore include: operation and maintenance expense; taxes; depreciation; and a return on the rate base.

Operation and maintenance expense are a matter of record and experience. Assuming equal efficiency in management, the amount is independent of the type of ownership or control of the utility.

Taxes collected through revenue by the privately owned utility must include all taxes which the utility is obligated to pay to federal, state, and local governments. For the publicly owned water works, the tax item may vary from none to all of the taxes required of the privately owned system, although in the publicly owned utilities where allowances are made for this item, the amount is often limited to local taxes.

Depreciation allowances are based on such annual percentages of the items of plant investment as may be considered necessary to accumulate the amount of the corresponding capital at the end of the useful life of the physical property. Under commission control, rates for depreciation are fixed or approved by order and are adjusted from time to time to accomplish their objective. Privately owned utilities are generally restricted in the use of depreciation funds. Relatively small amounts of cash are usually held in "working capital," and the balance may be invested in plant extensions. The use of such funds to retire debt is not permitted.

Frequently, with publicly owned and locally controlled properties, rates of depreciation are larger than necessary for normal replacements and extensions, and the surplus accumulated from this and other sources is used for major improvements, for debt retirement, or as a donation to the general fund of the municipality.

The *rate base* and *rate of return* are matters determined by court or commission decisions for all utilities subject to such control. For all publicly owned and locally controlled water works, no such machinery is available, and the determinations are made by local authorities, with or without the aid of consultants, accountants, or other experts. It is not uncommon, in such instances, for municipalities to use the so-called book value, where the figures exist, or the actual cash expenditures over the years, with or without the interest accumulations on property paid for out of bond issues.

Courts and commissions determine rate bases quite differently in the various states. The methods range from original cost (or prudent investment) less depreciation, which is recent practice with many commissions, to present reproduction cost less depreciation (or fair value), which is required by statute in at least one state. Obviously, a commission must fix a rate base and rate of return for a privately owned utility that will assure an income sufficient to attract the capital necessary to maintain and develop the corporation.

For the publicly owned and locally controlled water works, the rate base

and rate of return are not significant items in connection with financing. Money is borrowed on general-obligation, special-assessment, or revenue bonds. General-obligation or special-assessment bonds have a lien on all or a portion of the property in the city and are not affected by the value of the assets or the earnings of the water works. Revenue bonds are secured by a lien on the earnings of the water works, but the buyer is not especially interested in the value of the property involved. Rather, he is concerned with the net operating revenue available for interest and debt retirement.

If the gross revenue of a publicly owned water works is computed on the utility basis, the rate base and rate of return should be comparable to those of a privately owned property. The Wisconsin Public Service Commission is required by statute to adopt the basic principle that "a municipally operated water utility is entitled to the same rate of return as that permitted for privately owned utilities" (*9*). By the same logic, it seems proper to assume that a publicly owned property is not entitled to earn a higher rate than that which would be permitted a comparable privately owned property. A recent decision of the Wyoming commission ruled that a "municipal water plant is not entitled to as high a return as utility companies" (*10*), while, in Maine, it is reported that, "theoretically, a water district is not entitled to any 'return' or net income, but the commission always allows some leeway for contingencies or emergencies" (*11*).

From the record available (*12*), it appears, however, that the rate of return on book value varies in municipally controlled water works from no return to more than 20 per cent. This range is due chiefly to four factors: [1] amount of outstanding debt; [2] inaccurate records of book value; [3] appropriations for major improvements; and [4] diversions of water works funds to meet deficiencies in other municipal departments.

It is obvious that the revenue requirements of most municipally controlled water works are not premised on any rate base or rate of return, but on the cash requirements of the system, as determined by local conditions and policies. Hence, a cash basis affords an alternative and more realistic approach to the problem for the great percentage of municipal water works.

Cash Basis

The cash basis is similar to the budget basis of other city departments and, as such, is more easily explained and justified to city administrations. The total revenue is based on estimates of cash requirements, supported by operating experience and knowledge of future needs.

The items to be included may be separated into basic and optional classifications. The basic items are: operation and maintenance; debt requirements (interest and principal); replacements; and normal extensions and improvements. The optional items are: taxes; appropriations for major improvements, or reserves therefor; and contributions to other city departments. The basic items cover the essential requirements concerning which no water works manager, council, or commission will disagree; but the optional or additional items involve matters on which there is much difference

of opinion and which, in the last analysis, will be decided by local authorities.

Debt requirements should include the interest and repayment of all outstanding bonds—whether general obligation, special assessment, or revenue—the proceeds from which have been invested in water works property. Replacement estimates should be sufficient to provide for the current renewals and replacements of such units of equipment and property as are no longer serviceable and need to be replaced or rebuilt. The allowance for normal extensions and improvements should provide for the year-to-year costs for small main extensions, services, meters, hydrants, and similar minor items, but should not include sums to be set aside for major improvements. This item, together with that for replacements, may often be substantially equivalent to normal depreciation allowances. Taxes are controversial, but majority opinion would probably favor payments to the municipal government in lieu of all local taxes, provided the municipal government makes a reasonable payment to the water department to cover the fire protection service. If it is local policy to avoid debt, partially or entirely, in meeting the cost of major improvements, a reserve may be created and the corresponding funds kept apart, carefully invested and earmarked, without possibility of diversion for other purposes. Such a reserve may not, however, be legal in all states.

Diversion of water works funds to other city departments is the most controversial item among the optional additions to revenue. Although the practice is common, particularly in the larger cities and those in which normal property taxes yield inadequate revenue, it may be deprecated by persons concerned with the best interests of the water works. The danger inherent in such a practice is that, once adopted as a policy, it affords an opening wedge for further claims on water works revenue to the point of injury to water service. Striking illustrations of the inadequacy of existing water facilities due to fund diversions are common knowledge.

Illustrative Applications

The following applications illustrate the range in revenue determination using the two bases and with varying assumptions regarding the items involved. The figures are based on the records of a city of 100,000 population with a book value of approximately $8,400,000. In 1950 this municipality had a gross annual revenue of $490,564, paid no taxes, had a debt service charge of $51,125, and made an appropriation of $90,536 for extensions and betterments.

On the cash basis, therefore, this property operates with a gross revenue about as follows:

Operation and maintenance	$259,000
Debt requirements	51,125
Replacements, extensions, and improvements	90,536
Net income (1.07 per cent of $8,400,000)	89,903
Total revenue	$490,564

The minimum revenue, on the cash basis, for such a property could be the sum of the first three figures, or $400,661; and the maximum revenue probably should not exceed this latter sum, plus local taxes at 1½ per cent, plus perhaps 6 per cent on the book value, or a total of $979,536:

Operation and maintenance	$259,000
Replacements and extensions	90,536
Taxes at 1½ per cent	126,000
Major improvements or fund diversions (6 per cent of $8,400,000)	504,000
Total revenue	$979,536*

On the utility basis, one might estimate the revenue as follows:

Operation and maintenance	$259,000
Depreciation (1¼ per cent)	105,000
Taxes (1½ per cent)	126,000
Return (6 per cent)	504,000
Total revenue	$994,000

Next, assume the same property to be privately owned, with these figures applying: rate base, approximately $7,000,000 (or $8,400,000 less accumulated depreciation, plus working capital); annual depreciation allowance, 1¼ per cent of $8,400,000; local taxes, 3 per cent; federal income taxes, $304,000; and rate of return, 6 per cent of fair value (based on $3,500,000 in bonds at 4 per cent and $3,500,000 in stock at 8 per cent). The gross revenue then becomes:

Operation and maintenance	$259,000
Depreciation (1¼ per cent)	105,000
Taxes (3 per cent)	210,000
Return (6 per cent)	420,000
Federal income taxes	304,000
Total revenue	$1,298,000

* In Maine, "the revenue for the utility illustrated would be determined about as follows:

Operation and maintenance	$259,000
Taxes	0
Depreciation (1¼ per cent on $8,400,000)	105,000
Interest on indebtedness (4 per cent on $3,500,000)	140,000
Sinking fund provision (minimum, 1 per cent on $3,500,000)	35,000
Minimum revenue requirement	$539,000

"This minimum is often adjusted by the commission to allow the district to retire its indebtedness at a more rapid rate and to provide for foreseeable future increases in operation and maintenance" (*11*).

If the rate base were set at fair value, instead of prudent investment, the gross income requirement could be materially larger, depending upon the average age of the property, the allowable rate of return, the amount of taxes, and other elements.

The preceding figures demonstrate the wide range of total revenue (from $400,661 to more than $1,298,000) possible under the alternate assumptions, depending upon type of ownership, rate base, and rate of return (for privately owned utilities), and (for publicly owned and controlled properties) such matters as payments in lieu of taxes, financing methods, and contributions to other municipal functions.

Revenue From Suburban Areas

The rates to suburban areas should be computed on the utility basis. The assumption may be made that the water works is the property of the citizens of the municipality and that users outside of the city should pay a rate that, if applied to all such users, would provide for all operation and maintenance expense, plus local taxes, depreciation, and a reasonable return on the value of such portions of the property as may be devoted to the service of the outside areas, including all production and transmission facilities required to deliver the product to the city limits, but excluding the distribution, service, and fire facilities provided solely for serving the area within the city. The sum of all such costs, divided by the total annual production less transmission losses, gives an average sale price applicable to all outside users with normal load factors.

On such a theory, if the utility basis is used inside the city, as is done by

privately owned systems, or by publicly owned systems under commission control, there is no difference between city and suburban rates, except for charges that may be justified as extra costs in particular situations.

Section 2—Classification of Costs

In order to formulate rate structures, costs must be classified in some manner to permit their allocation to the several services and users. Two methods—the demand basis and the functional cost basis—are presented herein.

Demand Basis

It has been a general practice to divide costs into three groups: customer costs, capacity costs, and commodity costs. Customer costs include those arising out of the maintenance of services and meters and the labor and accounting expense required for reading, billing, and collecting. Customer costs constitute a relatively small proportion of the total. They are readily segregated, as are also the direct charges to fire protection, arising out of hydrants and their connections, and any other equipment provided solely for fire and for special purposes. Based on the usual definitions, capacity costs include those which arise out of providing plant and keeping it "ready to serve." Commodity costs are those which vary directly with the amount of water produced. The separation of capacity from commodity costs has, however, long been a subject of controversy. Strict compliance with these commonly quoted definitions leads to classifying a very large percentage of all costs as capacity costs and a relatively small percentage as commodity costs.

The theory upon which this practice is based was inherited from the electrical industry. It was originally set out by Hopkinson in England and by Henry L. Doherty in this country, treating of rates for electricity supply:

> [Based on this theory, the] cost of central station service can be generally divided into three classes:
>
> 1. Those elements of cost which are strictly proportional to the number of customers, such as billing, meter reading, accounting, collecting, meter testing, etc.
> 2. Those elements of cost which are proportionate to the maximum demand which a customer may make upon the plant and system of the public utility.
> 3. Those elements of cost which are in proportion to the actual amount of water, gas, or electricity actually used.
>
> Any system of rates which omits from proper consideration any great proportion of the costs referred to above results in an overcharge to some and too great liberality to others (*13*).

This theory needs to be modified for satisfactory application to water works. One aspect of the water works industry that differentiates it from other kinds of business is the relatively large proportion of the costs that are fixed, in the sense that they do not vary with output. Theoretically, almost all costs, except such items as coal, electricity, and chemicals, can be so classified. In the illustration presented later in this section (page 196), the capital costs alone, based on only 6 per cent of the capital investment to cover fixed charges, amount to about two-thirds of the total annual charges. Examples might be cited in which a very large percentage of total costs has been allocated to capacity costs. It is not uncommon to find nearly half the total expense assessed to customers as a demand or capacity charge and collected through a service or a minimum charge, or in a higher unit rate for the first step—in effect, a substantial

charge largely independent of the flow through the meter.

The *Manual of Water Works Practice* (*5*) considered this dilemma in 1925 and concluded that capacity costs computed in this manner would amount to "a considerable proportion of the total cost" but that "theory should not be carried to extremes, and, regardless of calculation, it is best to limit the service (capacity) charge in all cases to reasonable amounts. . . . [The] consumption (commodity) charges should, in all cases, carry the major part of the entire cost of service."

In an effort to bring uniformity in the classification of costs by this method, the committee suggests the following modified definitions:

Customer costs: These costs shall comprise all operation and maintenance and fixed charges arising out of service to customers, including meters and services, collection, and commercial expense, together with a suitable portion of general and administrative expense.

TABLE 1

Distribution of Capital

Item	Production and Transmission $	Distribution $	Customers' Facilities $	Hydrants and Connections $	Office $	Stores and Shop $
Organization					10,000	
Land and rights	93,000				50,000	70,000
Structures and improvements	590,000	150,000				
Power production equipment	44,000					
Steam pumping equipment	34,000					
Electric pumping equipment	220,000					
Purification equipment	59,000					
Plant in progress	318,000					
Transmission mains	1,730,000					
Feeder mains in progress	175,000					
Distribution mains		3,680,000				
Hydrants				332,000		
Office furniture and equipment					22,000	
Transportation equipment						45,000
Stores equipment						2,000
Shop equipment						6,000
Laboratory equipment						3,000
Tools and work equipment						17,000
Meters and services			750,000			
Subtotal	3,263,000	3,830,000	750,000	332,000	82,000	143,000
Distribution of office and shop	45,000	67,500	90,000	22,500		
Total	3,308,000	3,897,500	840,000	354,500	225,000*	

* Office and stores and shop distributed as follows: production, 20 per cent; distribution, 30 per cent; customers, 40 per cent; and hydrants, 10 per cent.

Capacity costs: These costs shall be limited to a portion only of the fixed charges of depreciation, taxes, and return. After suitable deductions for fire protection, customers' investment, and property devoted to special uses, the remaining fixed charges shall be divided between the capacity costs and

TABLE 2

Distribution of Operation and Maintenance Costs

Item	Production and Transmission $	Distribution $	Customers' Facilities		Hydrants and Connections $	Office $
			Commercial $	Meters and Services $		
Source of supply						
Labor and expense	12,300					
Maintenance	3,100					
Power and pumping						
Labor	21,000					
Power	93,700					
Miscellaneous	6,900					
Maintenance	3,300					
Purification expense						
Labor	1,100					
Chemicals	9,100					
Miscellaneous	200					
Maintenance	400					
Transmission	5,000					
Distribution						
Labor		14,000				
Miscellaneous		3,000				
Maintenance		8,000				
Hydrants					3,600	
Services				5,900		
Maintenance, general structures		300		200		500
Meters				4,900		
Customer accounting			45,200			
Administrative and general						17,300
Subtotal	156,100	25,300	45,200	11,000	3,600	17,800*
Distribution of office	3,560	5,340	5,340	1,780	1,780	
Total	159,660	30,640	50,540	12,780	5,380	

* Distributed to: production, 20 per cent; distribution, 30 per cent; commercial, 30 per cent; meters and services, 10 per cent; and hydrants, 10 per cent.

the commodity costs of normal users on a basis to be determined.

Commodity costs: These costs shall include all operation and maintenance expenses, except those chargeable to customers and to fire protection or other special services, plus the balance of the fixed charges not allocated to capacity or customer costs.

The application of the customer, capacity, and commodity costs to the formulation of rate schedules is discussed in Sections 3 and 4. The procedures for designing water rates have generally been based on trial-and-error assumptions applied to the sales records of the particular community. In Section 4, suggested procedures are presented.

Functional Cost Basis

An alternative method of classifying costs, which permits the establishment of definite rules for determining water

rates, is a functional distribution, as proposed in a Michigan Section committee report (*1*). In this method, operation and maintenance, as well as fixed charges, are separately allocated to the functions of: production, including source, treatment, pumping, and transmission; distribution; customers' services and meters; and hydrants and connections. Office and shop costs are first separately classified and then distributed by judgment to the four main classifications.

TABLE 3

Summary of Capital Investment and Operating Cost

Item	Capital Investment $	Operation and Maintenance $
Production and transmission	3,308,000	159,660
Distribution	3,897,500	30,640
Subtotal	7,205,500	190,300
Customers' facilities	840,000	63,320
Hydrants and connections	354,500	5,380
Total	8,400,000	259,000

By this means it is possible to provide the data upon which a distribution of costs may be made, first to fire protection (and any other charges to property) and, second, to special and low-load factor users, as discussed in Section 3. The balance of the costs are then allocable to normal users, through a service charge and commodity rates, in accordance with the specific rules outlined in Section 4.

Illustrative Applications

A typical distribution of capital and of operation and maintenance costs for a city of 100,000 population, with a book value of $8,400,000, is shown in Tables 1–4. These tables provide the bases for the allocation of expense in Section 3 and the determination of rate schedules in Section 4.

The figures presented in Table 3, which summarizes Tables 1 and 2, make possible the allocation of costs to fire protection and special users (Section 3) and to normal customers (Section 4). To derive from Table 3 the

TABLE 4

Annual Charges

Item	Fixed Charges $	Operation and Maintenance $	Total $
Production and transmission	198,480	159,660	358,140
Distribution	233,850	30,640	264,490
Subtotal	432,330	190,300	622,630
Customers' meters and services	50,400	63,320	113,720
Hydrants and connections	21,270	5,380	26,650
Total	504,000	259,000	763,000

annual costs against each classification of service, the desired or necessary gross revenue must first be determined by the methods outlined in Section 1. In the particular city from which the figures are taken, the gross revenue was reported as $490,564, leaving only $231,564 in excess of the costs of operation and maintenance shown in Table 3, or only about 2¾ per cent of the total investment. This property has substantially no debt, pays no taxes, and receives no payment for fire protection.

For the purposes of this discussion and the illustrative examples which follow, it has been assumed that the income received by this property should pay fixed charges of 6 per cent on the total investment plus the total expense for operation and maintenance. Obviously, the percentage figure used should yield the amount required by the specific utility to cover depreciation, taxes, and return. Assuming 6 per cent, the total income would be $763,000, allocated to functions as in Table 4.

Section 3—Allocation of Expense

This section considers briefly the questions involved in the allocation of expense between water users and taxpayers and between normal water users and special, or low load factor, users.

Water Users and Taxpayers

In most municipalities today, the water works performs more than one function. Generally, its primary function is to supply a necessary commodity to its customers, but it also affords certain benefits to the municipality as a whole. It safeguards public health, improves property values, and contributes to fire protection. Except for fire protection, which is dealt with below as a low load factor use, these benefits are intangible and their values are not determinable by rule. Whether or not they should bulk large in the allocation of expense is a matter upon which there is a difference of opinion.

Although it has been the practice in many publicly owned water works to allocate some part of the annual expense—usually some portion of the debt service—to the taxpayers, such allocations have been the result of the methods of financing rather than any theory of benefits. Financing has depended on local conditions and on the most advantageous method of borrowing or assessing costs, without any particular consideration of equity in the division of the financial burden between the water users and the taxpayers.

Prior to about 1920 most municipally owned water works were financed through the sale of general-obligation or special-assessment bonds. To the extent that the interest and bond retirement payments were taken from taxes, the practice constituted a contribution by property to the cost of the water works. In many cities, however, the debt service on these bonds was met out of the revenue from rates, with little or no contribution from the taxpayers. In fact, taxpayers have commonly been the beneficiaries of much free service, including water to public buildings, street and sewer flushing, fire protection, and cash diversions to the general fund.

During the past two decades much municipal water works financing has been accomplished through the sale of revenue bonds, supplemented by surplus cash from earnings. Normally, all of these funds come from water users, except where a fire protection charge is included in the tax budget. It is common practice, however, to finance extensions to the distribution system by assessments, or the equivalent, on the property to be served.

A recent suggestion (*7*, page 175) that would allocate a considerable part of the annual expense to the taxpayers proposes the "use of *general* tax funds to finance at least a part of the con-

struction or replacement of *major* structures," and the "use of *special* assessments to finance acquisition, construction, or replacement of *local* structures," with the "use of water charges to finance operation and maintenance" only. The rules for applying this plan are sufficiently clear to permit their use in practice.

Others (*14*) have proposed allocations of costs on a nearly equal basis between taxpayers and water users, but the principles supporting the logic of such allocations have not been presented.

Although there are situations in which it is necessary to make considerable use of the taxing power in order to finance new systems or provide major improvements for existing ones, these instances are exceptions rather than the rule. Such situations generally arise when it is desired to develop a water system in advance of the arrival of the anticipated customers (who may be expected later to use the system and pay the cost through rates). Reliance on the taxing power may also be dictated for utilities whose fixed charges are a preponderant part of the total cost of service. For example, in the financing of water and sewage services to such an area as the Washington Suburban Sanitary Dist., involving 200 sq miles of territory with a population of only 250,000, it has been necessary that property assume a substantial portion of the burden; or in the development of a remote and expensive source of supply, like that of Los Angeles, the financing of a major part of the cost must be based on a guarantee from property.

Generally speaking, however, the presently developed and established water systems need little or no financial assistance from taxes. A large proportion of such systems are able to collect through reasonable rates a sufficient income to operate, maintain, and develop adequate facilities. At the same time, many cities are hard pressed to find sufficient property tax revenue to meet the increasing costs of other municipal services and are seeking additional sources of income. Under these circumstances, it would seem to be unrealistic to propose generally that any considerable amount of utility revenue be collected through property taxes as payment for intangible benefits to property as a whole, no matter how alluring the theory upon which such proposals are based.

Although the sources of water works revenue are to be determined on the basis of all local factors, one may conclude that most of the income will be derived from the water users and that the portion received from taxes, assessments, or other levies will usually be limited to: fire protection; assessments on benefited property for main extensions; and occasionally some tax aid, grant, or donation to help finance a major improvement.

The preceding comments are intended to apply primarily to publicly owned and locally controlled water works. Publicly owned systems controlled by commissions are usually subject to the same regulations as privately owned properties. Gross earnings from utility rates, plus a fire protection charge, provide for operation and maintenance, depreciation, and taxes, as well as a limited return on the rate base; and, out of net earnings, the equivalent of dividends is frequently paid to the general funds of the city. Commission rulings appear to deny the right of cities to accumulate,

through rates, the surplus necessary to finance future major improvements.

Except for public fire protection charges, privately owned water works have no "legal authority . . . to make any charge or assessment against nonusers" (*7*, page 228). To a limited degree, however, privately owned systems extend lateral mains with the aid of customer contributions or deposits, subject to later refund, or through rate surcharges sufficient to meet the added expense.

Normal and Special Users

Users may be divided into normal and special classes, based on the ratio of their maximum demand to the average annual rate of use. Most water users may be assigned to the normal category, but there appears to be an increasing number of special users whose maximum demand, in relation to the average, is higher than normal because of seasonal or intermittent use. Among special uses one may include fire protection, air conditioning and refrigeration, lawn sprinkling, supplies to golf courses, other irrigation supplies, and those for certain commercial and industrial purposes.

Special users, except where the demands are offpeak, require more plant capacity in relation to average use than do the normal users. Hence, the cost of service to such special users is greater than for normal users by the amount of the fixed charges on the additional plant required.

Generally, single rate schedules have been applied heretofore to all types of water users, without regard to demand in relation to use. In recent years, in some areas, the summer use of water for sprinkling and the nonconserved use for air conditioning have placed such an increased burden on water systems that adjustments in water rates are desirable if each user is to pay for his service, as nearly as practicable, on the basis of cost.

To accomplish these adjustments, information is needed on the maximum-day demand assignable to each class of service—to domestic use, sprinkling, air conditioning, commercial and industrial use, and fire protection. On the basis of an allocation of plant capacity to normal and special users (including fire protection as a special use) fixed charges may be allocated to each use, either through an additional demand or service charge or through a modification of the rate structure.

Fire Protection

Numerous methods have been proposed in the past for determining the proper portion of water works costs chargeable to fire protection. Three of these methods, together with a discussion of some of the basic controversies involved in their application, have already been presented by the committee (*3*): the classic method of Metcalf, Kuichling, and Hawley (*15*), published in 1911; a method outlined in 1913 by Erickson (*16*), of the Wisconsin Public Service Commission, and elaborated upon by Alvord (*17*) in 1914; and the more recent basis employed by the Wisconsin commission, as described by Nixon (*18*) in 1937.

Two fundamentally different theories are involved in these methods. One theory (*15, 18*) assumes that the share of the applicable fixed costs chargeable to fire protection may be based on the ratio of the fire demand to the total demand for water, including fire, but that only the incremental operating and maintenance costs are to be included.

The other theory (*16, 17*) considers that both fire and general service should bear the burden of cost (both fixed and operating) "according to an apportionment of the existing plant based upon the relative costs of entirely separate systems" (*17*).

Under the first theory, the charge to fire is a relatively large proportion of the fixed costs in a small community and decreases with increased population. On the Kuichling basis, the percentages could vary, for example, from 77 per cent of the fixed costs with 5,000 population down to 13 per cent with 300,000 population, and include "between 5 and 10 per cent of the total annual operation and maintenance charge." It will, of course, be realized that percentages based on 1911 data may not apply today.

Under the second theory, nearly half of all fixed and operating costs, regardless of the size of the city, are chargeable to fire protection. Although, in earlier years, there were a few commission allocations (*19*) in which the revenue from fire approached 50 per cent of gross revenue for small towns, there has never been any general acceptance of the "separate-system" basis of allocation.

The application, by individuals and commissions, of these and other theories on the determination of the fire charge has led to widely varying results and has been the subject of controversy for four decades. Although most water works managers and engineers have generally accepted the propriety of charging for public fire protection, and courts and commissions have usually included allowances for this service in rate structures, such a charge is lacking in most municipally controlled water works. Privately owned properties usually charge for fire protection, but frequently in nominal amounts only.

Among the factors that have contributed to this state of affairs are: [1] a general feeling that the theories of computing the fire charge have overemphasized the cost of this service; and [2] the fact that a fire charge has been an additional item in a tax budget which is already inadequate for other municipal needs. Under such circumstances, if one hopes to effect any improvement in a confused situation, a more realistic approach is required, both in the method of computing the fire charge and in the manner of its collection.

In computing the charge, one should accept the premise that the prime function of the average municipal water works today is to supply a commodity, and that fire protection, although important to the safety of the community, is a supplementary service, the charge for which should not exceed the demonstrable additional costs involved in rendering this service.

The *direct* additional costs include: [1] the fixed and operating charges arising out of all plant and equipment installed solely for fire protection, such as hydrants and their connections and any pumps, mains, storage, or other equipment used only for fire service; and [2] the cost, at normal commodity rates, of the water used in fighting fires.

The determination of *indirect* costs —those costs that arise out of the additional plant capacity required for fire protection—has been a difficult hurdle in the past. The mechanics of this determination, particularly as applied to distribution facilities, have been com-

plicated even more by the improved definition of fire demands. Before 1948 it had been generally assumed that total fire demand was based on population in accordance with the standard schedule of the National Board of Fire Underwriters, adopted Dec. 14, 1916. Then the NBFU issued Bulletin 266, in which the character of the area protected, the degree of congestion, the size of the buildings, and the type of occupancy were taken into account, so that "material modifications" had to be made in many instances (*20*). The total fire requirements are now based on the extent of a mercantile district or on the size of and conditions surrounding industrial sections or areas of high-value buildings. Although 20,000 gpm remains "the maximum fire flow demand required in any city," regardless of population, "communities suburban to a metropolis," for example, may not need nearly the fire flow called for by the formula. Over much of the distribution system, the fire requirements may vary from as low as 500 to 1,500 gpm in single-dwelling residential areas; from 1,500 to 3,000 gpm in sections with individual apartment houses, schools, hospitals, or single factories; and up to 6,000 gpm in densely built residential areas.

It appears, on the basis of this modified concept of fire demand, that the indirect additional or incremental costs of fire protection cannot be determined with any degree of precision by the application of a ratio of fire demand to total demand applied indiscriminately to the annual charges of all or even the major parts of a water works property. Rather, this determination requires a subdivision of the cost of the property into two parts: those items needed for general service without provision for fire protection, and those that must be added in order to provide for both classes of service. This subdivision is simplified for the production facilities by certain basic considerations. Where the source of supply is a large reservoir, no part of the cost of such storage would be chargeable to fire. To the extent that excess clear well storage relieves treatment facilities, the ratio applied to such investment may be reduced. A proper charge for distribution storage should be made, however; and the pumping plants that deliver water into the distribution system may be apportioned on the basis of the relative demands of fire and other services.

The additional cost of distribution facilities may account for much of the cost of fire protection. An accurate determination would require cost estimates based on two systems—one for fire only and a second capable of meeting the combined demands of fire and general service. Although such estimates could be made by commissions and larger cities, with the aid of rate specialists, it appears that most determinations have been made without such analyses. The methods employed are discussed in various articles (*3, 7, 16–20*).

An alternative approach to the fire protection charge involves the assumption that *storage* may be provided *in lieu of capacity*. Such stored water may be assumed to be located in ground storage convenient to the mercantile or industrial areas and in controlled elevated storage to serve the periphery of the city. The assumptions, of course, are made solely to provide an alternative basis of computation and not to suggest that water

systems, in general, may find it either practical or desirable to substitute storage for pumping facilities and main capacities to meet the maximum demand for both fire and normal use.

If fire protection is to be charged with storage instead of capacity, the amount of storage to be assumed is shown in Table 5. To the expense of providing the necessary storage must be added the difference in cost between the mains required for general service and the larger ones required to deliver the water stored for fire protection to the hydrants. It may be reasonable to

TABLE 5

*Fire Storage**

Population	Flow Rate *gpm*	Duration of Pumpage *hr*	Total Storage Required† *mil gal*
5,000	2,250	9	1.2
10,000	3,000	10	1.8
40,000	6,000	10	3.6
100,000	9,000	10	5.4
200,000	12,000	10	7.2

* Based on NBFU requirements.
† Flow rate multiplied by duration.

assume that, if there were no need to provide water for fire protection, the secondary mains in general service could be smaller than the 6-in. mains which are now considered the minimum for areas to be "protected." On this basis, it would be logical to charge to fire protection the cost of a 4-in. differential in size applied to all the mains in the distribution system.

Applying this suggested basis for computing the fire charge—using the distribution of capital and expense in a city of 100,000, as presented in the tables in Section 2—the costs would be:

Hydrants and connections	
Fixed charges—6 per cent of $354,500 (Table 1)	$21,270
Operation and maintenance (Table 2)	5,380
Cost of water—1 per cent of total revenue (Table 4)	7,630
Storage and mains	
5.4 mil gal at 10 cents per gallon*—6 per cent of $540,000	32,400
Additional main costs†—6 per cent of $675,000	40,500
Total	$107,180

* Based on a combination of elevated and surface storage with pumps.
† Based on a differential of $0.75 per foot on 900,000 ft of distribution pipe.

The total of $107,180 is 14 per cent of the gross revenue of $763,000, approximately 21 per cent of the total annual fixed charges of $504,000, or $1.07 per capita per year.

If this basis of computation, using the same per capita units for both fixed and operating costs, were applied to cities of various sizes, the approximate per capita charges for fire protection would be as follows:

Population	Annual Charge *$/capita*
10,000	1.83
40,000	1.28
100,000	1.07
200,000	0.96
400,000	0.93
1,000,000	0.72

Two additional aspects of the subject of fire protection charges should be mentioned. These are taxes and corrections for deficiencies.

Taxes. It has been argued that the collection of a fire protection charge should obligate the water works to pay local taxes. In the preceding illustration, if local taxes are assumed at 1½ per cent on the capital investment, the amount of the tax would be approximately $126,000 annually, or approxi-

mately 18 per cent in excess of the fire charge.

Approximate figures, on the above basis of computation, indicate that taxes and the fire charge would be almost equal in a city with a population of 40,000; in smaller towns, taxes would be less than the fire charge; and, in larger, taxes would exceed the fire charge. This comparison provides some justification for the conclusion, not infrequently expressed, that offsetting the fire charge against local taxes is often a reasonable procedure.

Correction for deficiencies. The usual computation of a fire protection charge is based on the premise that the plant is capable of meeting both the general service and the fire demand simultaneously and adequately. This is frequently not the fact, however.

It has been proposed (*21*; *7*, page 232) that the fire charge should be reduced in proportion to the plant deficiency, based on the NBFU standard grading schedule (*22*). In this schedule, 32 items of water supply deficiency are considered. The maximum number of deficiency points assignable to the water system is 1,700, out of a possible total of 5,000 for all factors. A first-class city is one with no more than 500 points of deficiency, which may be distributed among water supply, fire department, fire alarm, police, building laws, fire prevention, and structural and climatic conditions. Many of these deficiencies may be corrected without material capital expenditures.

There is certainly no simple relationship between the number of deficiency points and the percentage by which the fire charge should be reduced on that account. In a deficient plant, an adequate supply for fire may be obtained with pumpers at hydrant pressures as low as 5 psi. It is recognized, of course, that excessively low hydrant pressures are a health menace, but it remains a fact that considerable water for fire will be obtained by pumpers regardless of the health aspects of low pressures. The standard requirement of the underwriters is "a minimum water pressure, during flow, of 20 [psi] . . . , except that a minimum of 10 [psi] is permissible" under certain conditions relating to hydrant size and distribution. At such pressures, the general service suffers, but the fire service receives its requirements in whole or in part; hence, there is logic in the contention that the proportion of plant capacity chargeable to fire is increased rather than decreased when the plant is deficient. Because of the complexity of the problem, any reductions in the fire protection charge should be based on an analysis by experts working with the underwriters.

Alternative methods of collecting fire charge. It has usually been assumed that a fire charge is an item of the tax budget and therefore collectible on the basis of total assessed valuations. Obviously, there is a considerable inequity in such a method. Vacant property pays for fire protection, although there is no fire hazard. Assessments made on the basis of structures only would be more equitable, but customers with high-cost, fireproof buildings would pay a greater amount for protection than others with less substantially constructed buildings of equal size which are of less value and may constitute greater fire hazards.

Another method would be to collect the fire charge with the water bill, in one of several ways. The first might be a charge, as above, based on the

assessed valuations of the structures of the customers. Instead, the charge might be made proportional to the product of the assessed valuation of the structure and the applicable insurance rate of the underwriters. Such a basis would entail considerable statistical work at the outset, even if the data were readily available. With the record once set up, however, it might not be too difficult to maintain. Certainly this plan would provide a more equitable distribution of the fire charge than the first method.

A simpler and more generally used method is to include the fire charge in the commodity rates or make it a part of the demand charge. If it is included in the commodity rates, the larger users of water will pay more in proportion to their protection than the smaller users, and much of the burden may fall on the so-called wet industries. If the charge is collected as a demand charge, based on meter sizes, a large part of the burden would be borne by the mass of domestic customers. It should be possible, however, to adjust the distribution of the demand charge to eliminate the obvious inequities. Using the previously mentioned city of 100,000 population as an example, Table 6 illustrates a distribution of the fire charge on the basis of group ratios of meters, as proposed in Section 4 for the distribution of customer demand charges (page 210).

Sprinkling, Air Conditioning, and Refrigeration

After allocations of capital and operating expenses have been made to the fire protection service, attention is given to the remaining special users whose requirements call for considerable plant. The most common of these special uses are sprinkling and air conditioning. In areas with warm, dry summers both types of use may be of consequence. In hot, humid areas, only air conditioning may be a problem, while, in cool, arid sections, sprinkling may result in a sizable water demand but air conditioning may be unimportant.

Although sprinkling may be an item of consequence for several hours of the day in some areas, it frequently causes a sharp afternoon or early-evening peak that places an added, short-term demand on all facilities. Generally, however, this peak may be substantially equalized by elevated storage or repumped surface storage. If so equalized, this portion of the additional demand mainly affects the distribution system between the storage and the customers' services. If the peak hour use is not equalized, the sprinkling demand requires additional capacity in both production and distribution facilities.

If a utility serves an entirely residential area, there is no need to make an allocation against sprinkling, because it is reasonable to assume that all customers sprinkle. Where, however, there is a sizable commercial and industrial load, much of which may be of the high load factor type, any extraordinary demand, such as that due to sprinkling, should assume a proper share of the additional expense. In other words, where sprinkling is an important factor in fixing plant capacity to meet the demands of the maximum day, it may be desirable to distribute the additional cost among the users of the sprinkling privilege. This may be accomplished by a suitable de-

mand charge, with the water used billed at the normal water rates.

Air conditioning and refrigeration differ from sprinkling in that the maximum demand usually lasts 10 hr or more on many consecutive days, and may not be handled practically with distribution storage. Air conditioning may start at 7:00 AM and continue until 5:00 PM for stores and offices. Restaurants will use water for longer periods, and particularly in the evenings. Home and hotel air conditioning may also continue for longer periods. These last three types are comparatively new water uses, which occur during the hours when sprinkling has historically placed its heavy loads upon water systems.

Here again, in areas where the air-conditioning and refrigeration load becomes an important factor in fixing plant capacity to meet the demands during the maximum day, the additional fixed charges may be assessed against users of the service, as an additional demand charge, measured or estimated, in gallons per minute of maximum demand; and the water used may be billed at the normal commodity rates. Alternatively, the entire cost of this service may be collected through an air-conditioning and refrigeration commodity rate.

Application. To make precise applications of the demand charges for sprinkling and air conditioning and refrigeration requires data based on system load records, separating the daily load curve of the maximum day into its component normal and special demands. The allocation of property to special uses, however, necessitates information not readily available, and the development of principles of application not as yet well defined.

For the purposes of this report, an oversimplified computation is illustrated, based on the pumpage record of the city referred to in Section 2. This record showed the following rates of pumpage on Jun. 12, 1952, the

TABLE 6

Distribution of Fire Charge by Meter Group Ratios

Meter Size in.	No. of Meters	Group Ratio	Equivalent No. of ¾-in. Meters	Annual Charge	
				Per Meter* $	Total $
⅝	23,586	1	23,586	2.25*	53,068.50
¾	909	2	1,818	4.50	4,090.50
1	772	4	3,088	9.00	6,948.80
1½	166	10	1,660	22.50	3,735.00
2	201	25	5,025	56.25	11,306.25
3	96	45	4,320	101.25	9,620.00
4	66	90	5,940	202.50	13,360.00
6	10	170	1,700	382.50	3,825.00
8	1	300	300	675.00	675.00
		Total	47,437		106,629.05

* The charge for a ¾-in. meter is obtained by dividing fire service cost ($107,000) by total number of equivalent ¾-in. meters (47,437). For larger sizes, the ¾-in. charge ($2.25) is multiplied by the corresponding group ratio.

maximum day (normal and special rates of use are estimated):

Item		Rate *mgd*
Max. day		34.1
Max. hour (7 PM–8 PM)		54.4
Day rate (9:30 AM–4:30 PM)		
Sprinkling	10	
Air conditioning	12	
Other uses	23	
Total day rate		45.0

In this instance, the maximum hour was not equalized by storage. It could have been equalized with approximately 1 mil gal of available or controlled storage, at an annual cost of approximately 6 per cent of $100,000 or $6,000.

Based on the above record, plant may be allocated to the several uses in accordance with the proportion of the rate for each use relative to the total rate of use during the hours from 9:30 AM to 4:30 PM (the ratio of sprinkling to total use is 10:45, or 22.3 per cent; for air conditioning, the ratio is 12:45, or 26.7 per cent). The assumption is made that the hourly peak is equalized by storage, and the cost of the storage is charged to the use producing the peak (assumed, in this instance, to be sprinkling).

In Table 7, the percentages given in the preceding paragraph are applied to the fixed charges shown in Table 4 (page 196), less the fixed charges allocable to fire protection (see page 202). The fixed charges on peak storage are allocated to sprinkling.

Demand charge for sprinkling. The total of $84,800 per year allocated to sprinkling in Table 7 corresponds to a charge of approximately $3.50 per year for 24,500 ⅝-in. and ¾-in. meters. This charge may be added to the demand charge developed in Section 4 for normal users (see Table 14, page 216).

TABLE 7

Allocation of Fixed Charges to Sprinkling and Air Conditioning

Item	Total Annual Charges $	Fire $	Balance $	Sprinkling (22.3%) $	Air Conditioning (26.7%) $
Production	198,480	32,400	166,080	37,000	44,300
Distribution	227,850	40,500	187,350	41,800	50,000
Storage	6,000		6,000	6,000	
Total	432,330	72,900	359,430	84,800	94,300

Demand charge for air conditioning. The air-conditioning total of $94,300 per year, if allocated to the 8,000 tons of nonconserved air-conditioning and refrigeration equipment now installed in the city under discussion, corresponds to a charge of approximately $12 per year per rated ton. This would be a surcharge, with all water used being charged at the regular water rate schedule.

It is of interest to note that, in an order dated Jul. 1, 1952, the Arkansas Public Service Commission approved "a monthly demand charge of $2.50 per rated ton of capacity on customers using water in connection with air-

conditioning units having a rated capacity of 3 tons or more without recirculatory cooling equipment, for the months of May, June, July, August, and September of each year." This amounts to $12.50 per ton per year.

Other Special Users

In many utilities, there will be other customers with load patterns that call for special analysis. These customers may be other utilities that purchase water in large quantities but have the load characteristics of domestic users rather than large industrial users. There may be a large component of sprinkling and air conditioning in such a demand. Also golf clubs, greenhouses, truck gardeners, swimming pools, and similar users may impose large summer peak loads, which may need to be analyzed separately, or as another special use group, so that their water rates may be properly established. In some places, too, one, or a few, industries may take a large part of the plant output. Studies of their specific loads will be necessary to prevent either subsidization of, or discrimination against, such large users.

Section 4—Rate Schedules for Normal Users

In Section 3, the customers of a water system were classified as normal and special users, and it was proposed that those portions of the fixed charges arising from the plant specifically required to meet the demands of the special users be allocated to them on the basis of their individual demands. This section discusses the methods of formulating rate schedules through which the balance of the fixed charges and all operation and maintenance expense may be distributed among *all* customers, as nearly as possible in proportion to the cost of supplying the commodity.

Costs have been classified in Section 2 in two ways: into customer, capacity, and commodity costs; and into the *functional* costs involved in production, distribution, customers' commercial expense, customers' services and meters, and hydrants and connections. The development of rate schedules, using these cost classifications, is discussed below under the demand (or capacity) basis and under the functional cost basis.

Demand Basis Service Charge

Two of the problems involved in the demand basis are the determination of the amount of the demand or capacity costs distributed as a service charge (discussed in Section 2) and the distribution of this portion of the costs to customers.

A basis for determing the amount of the capacity or demand charge proposed in Section 2 is that the charge be limited to a portion only of the remaining fixed costs, after suitable deductions have been made for fire protection, customers' investment, and property devoted to special uses. In order to arrive at an acceptable portion of fixed costs chargeable to capacity or demand, certain assumptions must be made for the sake of reasonable equity.

1. Total Demand Costs

The total of the so-called demand costs may be assumed to be limited to 50 per cent of the capital costs of depreciation, taxes, and return on the

investment of that part of the plant devoted to normal uses, the balance of the capital costs being charged to the commodity.

Capital costs are as much a part of the cost of production as labor, fuel, electricity, and other operation and maintenance expense. No business produces goods without capital costs. Therefore, some part of depreciation, taxes, and interest should be included in the cost of the commodity. If all customers used water at a uniform rate, plant size would need to be just equal to the sum of their requirements. Owing to variations in the rates of demand, however, the plant must be made larger than that necessary to supply the average load. Excluding special uses, it is not uncommon to experience an average daytime delivery rate on the maximum day of approximately twice the average annual rate. Under such conditions, half of the capital costs would appear to be chargeable to the commodity and the other half to demand. If the average daytime delivery rate on the maximum day, for normal use, were greater or less than twice the average annual rate, modifications in the 50–50 division would be warranted.

Possibly further justification for a 50–50 arbitrary division of capital costs is found in a recent supreme court case (*23*) which "sustained the Federal Power Commission in allocating return and income taxes, 50 per cent to volume and 50 per cent to demand." The court ruled that "a treatment of transmission costs by which 50 per cent of the return is assigned to capacity costs and 50 per cent to volumetric costs is proper, as against the contention that the entire return should be apportioned to capacity costs."

2. Equitable Distribution

The second problem in applying the demand basis has been to find a method for the equitable distribution of demand costs between users. The theory that has been followed involves the distribution of such costs in accordance with the relative capacities of the individual meters. But relative capacities of meters vary with the manufacturer, the type of meter, and the difference in permissible pressure loss. In actual application, the distribution of costs in this manner has often resulted in the collection of most of the demand costs from the domestic customers, who constitute the great bulk of the water users and are served largely by ⅝-in. meters.

In the city used for illustration in this report, the application of commonly employed capacity ratios will show that the 23,586 ⅝-in. meters, constituting 90 per cent of the total, would register approximately 37 per cent of the entire plant output and would bear about 75 per cent of the total demand charge. Another striking illustration is provided by a city where the transfer of 64 per cent of the total revenue (an amount computed to represent the "ready-to-serve" costs, as usually defined) from the commodity charge to the demand charge more than doubled the average charge for service through the ⅝-in. meter and reduced the average charge through a 12-in. meter to less than one-third (*3*).

One argument for such a transfer of burden from industrial to domestic customers has appeared in the literature since the early days of the rate controversy. Large allocations to the service charge have been made on the theory that one purpose of such a charge, which is independent of the

meter record, is to "stabilize" income. "If, due to the ups and downs of prosperity," too much dependence is put on the commodity charge, "the revenue will at times become inadequate" (*24*). In cities where a large proportion of the output is sold to industries, business depressions or long strikes may seriously reduce revenue unless some of the loss in water sales is recouped through a substantial demand charge. Another objective of the larger demand charge has been to make possible a "promotional" commodity rate—sometimes referred to as a rate based on incremental costs—that will enable a water works to justify sales to "a larger consumer . . . at any rate which will add to the net revenue of the plant, even though the rate is below the average cost as built up by administration, operating, depreciation, interest, and profit" (*24*). Such promotional rates have been used in the past to subsidize new industries or to retain a customer who might otherwise seek a separate source of supply. However convincing such premises may appear in particular instances, their adoption as a general basis would be contrary to the assumption that rate structures should, insofar as practicable, distribute all costs to customers on the basis of the expense of supplying the commodity and rendering service.

The difficulty of loss of revenue during depressions can be partially overcome by an adequate schedule of minimum charges for each size of meter. Such a minimum schedule is presented later in this report.

As for the inequities arising out of the use of the capacity ratios of individual meters, it has been suggested recently that the development and application of a demand meter would afford a solution. The momentary maximum demand of any single dwelling, however, is not a measure of that particular customer's effect on plant capacity. The actual maximum demand on a water system never equals the total combined potential demand of all users. If all meters in Detroit, for example, made a simultaneous demand equal to the sum of their individual capacities, at 5 psi loss, the total demand on the system would approximate five times the actual system capacity. Obviously, the water system is designed to meet no such theoretical total demand but rather the actual combined rates of use by all customers at a time of maximum demand. To obtain such a record from all customers would be impracticable. The usefulness of maximum-demand meters will probably be confined, therefore, to *entire* residential areas, special users, large industries, and suburban communities.

Demand costs may, however, be distributed on the basis of ratios that reflect the maximum demands of meters in *groups* of sizes rather than the capacity ratios of individual meters. Such a basis would aim at taking into account the diversity between customer groups and between customers within specific groups. For instance, all domestic customers will not require water at the maximum rate simultaneously. This diversity is normally larger within larger groups. It will probably be largest in the domestic customer group, less in the commercial, and still less in the industrial.

The data upon which to base such group ratios are generally lacking, but certain assumptions may be made as a basis for approximate ratios. It may

be assumed that the maximum simultaneous demand of all the meters in a residential area could be six times the average rate of use; that the maximum demand of large meters serving an industrial area would be nearer twice the average rate of use; and that meters of intermediate size can be given intermediate ratios. The ratio used for, say, the residential group of meters, when applied to the total of such sizes of meters, should yield a result in "demand on the plant" equal to the total actual residential demand. Likewise, the ratios of all groups, when applied to all meters, should result in a "total maximum demand" equal to the total plant capacity available for normal users.

Table 8 shows the effect of such assumptions, applied to data for Detroit. The group ratios are compared with the individual capacity ratios for meters of the disk and current types.

3. Other Service Costs

In addition to the demand costs which it is proposed to distribute among all customers on the basis of the meter group ratios, three other classes of costs should be included in a service charge:

a. All accounting, meter-reading, billing, collecting, and bookkeeping costs and a share of the general and administrative costs may be distributed equally among all customers.

TABLE 8

Meter Group and Individual Capacity Ratios

Meter Size *in.*	Avg 3-Month Consumption* *cu ft*	Multiplier	Maximum Rate *cu ft*	Group Ratios		Individual Capacity Ratios†	
				Computed	Rounded	Disk Meters	Current Meters
⅝	2,406	6	14,436	1	1	1	
¾	4,415	6	26,490	1.84	2	1.5	
1	11,369	5.5	62,530	4.33	4	2.8	
1½	25,591	5.5	140,740	9.8	10	4.3	7.5
2	70,802	5.0	354,060	24.6	25	8.7	12.3
3	167,333	4.0	669,332	46.3	45	13.2	25.4
4	521,558	2.5	1,303,895	90.5	90	19.5	36.0
6	1,232,684	2	2,465,368	171	170	34.5	70.0
8	2,238,557	2	4,477,154	310	300		135.0
10	3,644,078	2	7,288,156	505	500		173.0
12	8,170,500	1.75	14,298,375	993	1,000		187.0

* Detroit data (*1*).
† Based on data from a well known manufacturer.

b. All other customer costs, both capital and operation and maintenance, chargeable to meters and services, may be distributed to meters on the basis of plant records or, lacking such records, on ratios that represent approximately the installation costs of the meters and services.

c. Sprinkling costs, as developed in Table 7, may be distributed to ⅝-, ¾-, and 1-in. meters on the basis of their group capacity ratios.

Demand Basis Commodity Rates

The demand, accounting, and customer costs having been distributed through a service charge, the remaining costs are charged and collected through commodity rates. The standard form of rate schedule adopted by AWWA on May 24, 1923, suggested either three or four "slides" and fixed the quantity of water to be delivered in each slide, but the unit prices were left to be determined, with the qualification "that the ratio between the first and third rate should be limited to about 2 to 1, . . . and the amount of slide between the first and fourth rates should not exceed the ratio of 3 to 1" (*5*, page 460). This general plan is

TABLE 9

*Distribution of Annual Costs**

1	2	3	4	5	6	7	8
Item	Totals $	Fire $	Sprinkling $	Air Conditioning $	Balance to Other Services $	Balance Divided Between	
						Service Charge (50%) $	Commodity Rates (50%) $
Capital Costs							
Production	198,480	32,400	37,000	44,300	84,780	42,390	42,390
Distribution	233,850	40,500	47,800	50,000	95,550	47,775	47,775
Customers' meters and services	50,400				50,400	50,400	
Hydrants	21,270	21,270					
Subtotal	504,000	94,170	84,800	94,300	230,730	140,565	90,165
Operation and Maintenance Costs							
Production	159,660	7,630			152,030		152,030
Distribution	30,640				30,640		30,640
Customers							
Commercial	50,540				50,540	50,540	
Meters and services	12,780				12,780	12,780	
Hydrants	5,380	5,380					
Subtotal	259,000	13,010	0	0	245,990	63,320	182,670
Total	763,000	107,180	84,800	94,300	476,720	203,885†	272,835‡
Per cent of total	100	14.1	11.1	12.3		26.7	35.8

* Figures in Column 2 taken from Table 4 (page 196); in Column 3, from page 202; in Columns 4 and 5, from Table 7 (page 206).

† Comprising: demand charge, $90,165; commercial expense, $50,540; and meters and services, $63,180.

‡ Redistributed on the basis of meter readings.

adhered to in the application that follows.

Application of Demand Basis

Based on the costs in Table 4 (page 196) and the allocation to fire (page 202), sprinkling, and air conditioning and refrigeration (Table 7, page 206), Table 9 illustrates a distribution of costs to the special uses and to the service charge, only about 24 per cent of the total costs would be collected through commodity rates, while, if all demand costs were allocated to commodity rates, approximately 54 per cent of the total costs would be collected on the basis of meter readings. The latter allocation approximates the distribution discussed under "Functional Cost Basis" (page 213), in which the service charge includes only customer costs from commercial expense and meters and services, and does not include demand costs.

TABLE 10

Distribution of Service Charges

1	2	3	4	5	6	7	8	9	10	11
Meter Size in.	No. of Meters	Commercial Expense*		Demand†			Meters and Services‡			Total Quarterly Service Charge $
		Ratio	Quarterly Charge per Meter $	Ratio	Equivalent No. of ¾-in. Meters	Quarterly Charge per Meter $	Ratio	Equivalent No. of ¾-in. Meters	Quarterly Charge per Meter $	
⅝	23,586	1	0.50	1	23,586	0.50	1	23,586	0.50	1.50
¾	909	1	0.50	2	1,818	1.00	1.5	1,364	0.75	2.25
1	772	1	0.50	4	3,088	2.00	2.25	1,737	1.10	3.90
1½	166	1	0.50	10	1,660	5.00	4.0	664	2.00	7.50
2	201	1	0.50	25	5,025	12.50	6.0	1,206	3.00	16.00
3	96	1	0.50	45	4,320	22.50	10.0	960	5.00	28.00
4	66	1	0.50	90	5,940	45.00	20.0	1,320	10.00	56.00
6	10	1	0.50	170	1,700	85.00	35.0	350	17.50	103.00
8	1	1	0.50	300	300	150.00	50.0	50	25.00	175.00
	25,807				47,437			31,237		

* Commercial expense ($50,540) divided by total meters (25,807) equals $1.96 per year, or approximately $0.50 per quarter, per meter.

† Demand ($90,165) divided by total equivalent ¾-in. meters (47,437) equals $1.91 per year, or approximately $0.50 per quarter, per equivalent ¾-in. meter.

‡ Meters and services ($63,180) divided by total equivalent ¾-in. meters (31,237) equals $2.02 per year, or approximately $0.50 per quarter, per equivalent ¾-in. meter.

service charge and commodity rates, in the detail needed to compute a rate structure.

This distribution is premised on the allocation of demand costs equally between the service charge and the commodity rates. Even so, only about 36 per cent of the total costs is collected on the basis of meter readings. If all demand costs were to be included in

Service Charge Distribution

The distribution of the service charge of $203,885 (Column 7 of Table 9) is presented in Table 10. Commercial expense amounts to $50,-

540; the demand charge covers capital costs of $42,390 from production and $47,775 from distribution, a total of $90,165; and the charge against meters and services includes a capital charge of $50,400 plus an operation and maintenance cost of $12,780, making a total of $63,180.

The distribution of the sprinkling charge of $84,800 (Column 4, Table 9) among the ⅝-, ¾-, and 1-in. meters, on the same basis as is used in Column 7 of Table 10 to distribute the demand charges, would result in charges of $3.00 per year for the equivalent of 28,942 ⅝-in. meters. The sprinkling charges to be added to Column 11 of Table 10 would then be $0.75 per quarter for ⅝-in. meters, $1.50 for ¾-in., and $3.00 for 1-in. meters (see Table 14, page 216).

Computation of Commodity Rates

In compliance with the form of rate schedule outlined in the *Manual of Water Works Practice* (*5*), the unit rates applicable to wholesale, intermediate, and domestic customers may be derived from the costs in Column 8 of Table 9, taken together with the production and sales records of the particular community.

To determine the wholesale rate, add the capital costs of production ($42,390) to the operation and maintenance costs of production ($152,030). Divide this total ($194,420) by the total annual output (in this instance, 4,530 mil gal), to obtain a figure of 4.3 cents per 1,000 gal.

The average cost of distributing water may be determined as follows: from Column 8 of Table 9, the total distribution costs are $78,415; divide this total by the sales to all intermediate and domestic customers (estimated at 2,580 mil gal per year) to obtain a figure of approximately 3 cents per 1,000 gal. The average rate to these customers would then be 7.3 cents per 1,000 gal.

The following unit rates would produce slightly more than the total desired revenue of $272,835 (Column 8, Table 9):

Class	Quantity *mil gal*	Rate *¢/1,000 gal*	Revenue *$*
Wholesale	1,950	4.3	83,850
Intermediate	910	5.8	52,780
Domestic	1,670	8.2	136,940
Total	4,530		273,570

A minimum charge can be worked out as illustrated in Table 13 (page 215).

Functional Cost Basis

The functional cost basis was advocated in 1948 by the Committee on Water Rates of the Michigan Section (*1*). It is not new in theory, but is a reversion to the basis adopted in 1923 by an AWWA rate committee under the chairmanship of Allen Hazen (*6*) and is in accord with a recommendation of a similar committee of the New England Water Works Assn. It consists of a service charge, based on the size of the meter, including only customer costs (commercial expense plus meters and services *), with all so-called demand costs * collected through the commodity rates. As recommended in the *Manual of Water Works Practice* (*5*), the commodity charge is applied in three steps—through wholesale, intermediate, and domestic rates.

* See footnotes to Table 10.

This basis is applicable to the average community and to the average customer using year-round service in a normal manner. It does not provide for special users making intermittent or abnormal demands on the water system. It is premised on the theory that a more substantial equity will be achieved between normal users by collecting the fixed charges on the basis of the meter reading rather than arbitrarily on the basis of the size of the meter as a measure of the hypothetical demand of the customer. It avoids the problems involved in the separation of total costs into demand and commodity costs and their redistribution to customers.

TABLE 11

Service Charge on Functional Cost Basis

Meter Size *in.*	Quarterly Charge per Meter		
	Commercial Expense* $	Meters and Services† $	Total $
⅝	0.50	0.50	1.00
¾	0.50	0.75	1.25
1	0.50	1.10	1.60
1½	0.50	2.00	2.50
2	0.50	3.00	3.50
3	0.50	5.00	5.50
4	0.50	10.00	10.50
6	0.50	17.50	18.00
8	0.50	25.00	25.50

* From Table 10, Column 4.
† From Table 10, Column 10.

The rules for the application of this method, substantially as proposed by the Michigan Section Committee, are as follows:

Meter Service Charge

The meter service charge is to include:

1. All commercial expense and a suitable portion of administrative and overhead costs, the total of which is to be divided *equally* among all accounts. This apportionment should, however, reflect any known variations in cost, such as arise from variations in the frequency of meter readings.

2. All expense arising out of meters and services, with a share of administrative expense and overhead, the total of which may be distributed among accounts on the basis of the *meter* cost.

3. A charge for water sufficient to make a minimum bill, based on the commodity rates and reasonable minimum quantities for each size of meter. Such minimum bills will tend to control the size of meters and maintain the minimum necessary revenue through periods of fluctuating demands for water.

Commodity Unit Rates

1. The *wholesale unit rate* is obtained by dividing the total of all production and transmission expense (capital costs plus all operation and maintenance) by the total annual sales of water. Transmission mains are defined as those which convey water to the distribution system and are generally without service taps.

2. The *intermediate unit rate* is obtained by adding the intermediate increment to the wholesale rate. The intermediate increment is obtained by dividing the total expense arising out of distribution mains larger than 6 in. by the water sold through all meters, except sales at the wholesale rate.

3. The *domestic unit rate* is obtained by adding the domestic increment to the intermediate rate. The domestic increment is obtained by dividing the total expense arising out of mains 6 in.

and smaller by the water sold through all meters ¾ in. and smaller.

Application of Functional Cost Basis

Computation of service charge. Based on the costs in Column 7 of Table 9, the amounts to be collected through the service charge are: commercial expense, $50,540; plus meters and services ($50,400 plus $12,780), $63,180; total, $113,720. These amounts were distributed by meter sizes in Table 10 and are as shown in Table 11.

TABLE 12

Step Quantity Limitations
(Applied to Detroit Data)

Rate Step	Max. per Quarter	
	cu ft	*gal*
Michigan Section Basis		
Domestic	8,830	66,000
Intermediate*	141,600	1,060,000
Manual (5) Basis		
Domestic	10,000	75,000
Intermediate	90,000	675,000

* Including 2-in. meters.

Computation of commodity rates. The commodity rates may be computed as follows:

The *wholesale rate* is obtained by adding the capital and operation and maintenance costs of production (Table 9, Column 6) and dividing this total by the total annual sales: ($84,780 + $152,030) ÷ 4,530 mil gal = 5.25 cents per 1,000 gal.

The *intermediate increment* is obtained by taking one-half the total distribution costs (Table 9, Column 6) and dividing by the total annual sales except sales at the wholesale rate (the nonwholesale figure is estimated at 57 per cent of the total): ½($95,550 + $30,640) ÷ 2,580 mil gal = 2.44 cents per 1,000 gal. Adding 2.44 to 5.25 gives 7.7 cents as the intermediate rate.

The *domestic increment* is obtained by taking one-half the total distribution costs (as above) and dividing by 1,670 mil gal (sales at domestic rate, estimated at 37 per cent of total sales). The resulting increment is approximately 3.8 cents per 1,000 gal, so that the domestic rate is 11.5 cents per 1,000 gal.

TABLE 13

Minimum Bill

Meter Size *in.*	Min. Quantity per Quarter *gal*	Quarterly Charge *$*
⅝	9,000	2.00
¾	18,000	3.30
1	36,000	5.75
1½	90,000	12.70
2	225,000	24.00
3	400,000	39.00
4	800,000	74.00
6	1,500,000	118.00
8	2,700,000	189.00

These unit rates would produce slightly more than the $363,000 required to meet the costs in Column 6 of Table 9 ($476,720 total annual costs less $113,720 customer charges):

Class	Quantity *mil gal*	Rate *¢/1,000 gal*	Revenue *$*
Wholesale	1,950	5.25	102,375
Intermediate	910	7.7	70,070
Domestic	1,670	11.5	192,050
Total	4,530		364,495

TABLE 14

Comparison of Schedules

Meter Size *in.*	Demand Basis		Functional Cost Basis	
	Service Charge* $	Sprinkling Charge $	Service Charge† $	Sprinkling Charge $
⅝	1.50	0.75	1.00	0.75
¾	2.25	1.50	1.25	1.50
1	3.90	3.00	1.60	3.00
1½	7.50		2.50	
2	16.00		3.50	
3	28.00		5.50	
4	56.00		10.50	
6	103.00		18.00	
8	175.00		25.50	
Water Use—*gal*	Commodity Rates—*cents per 1,000 gal*			
First 75,000	8.2		11.5	
Next 675,000	5.8		7.7	
Over 750,000	4.3		5.25	

* From Table 10.
† From Table 11.

Step Quantity Limitations

With regard to step quantity limitations, the Michigan Section committee report (*1*) suggested that, "as an initial determination . . . , the domestic rate apply up to a quantity equal to twice the average consumption through all domestic meters, ¾ in. and ⅝ in.; that the intermediate rate apply up to a quantity equal to twice the average consumption through all intermediate meters; and that all quantities over the intermediate limit fall under the wholesale rate." Table 12 compares the effect of these limitations and the ones recommended in the *Manual of Water*

TABLE 15

Average Quarterly Bills (Using Detroit Data)

Meter Size *in.*	Avg Quarterly Sales per Meter *gal*	Demand Basis		Functional Cost Basis	
		Quarterly Bill $	Price per 1,000 gal *cents*	Quarterly Bill $	Price per 1,000 gal *cents*
⅝	18,000	3.73	20.7	3.82	21.2
¾	33,000	6.46	19.6	6.54	19.8
1	85,000	13.63	16.0	14.00	16.5
1½	190,000	20.32	10.7	19.99	10.5
2	530,000	49.15	9.3	47.17	8.9
3	1,250,000	94.85	7.6	92.36	7.4
4	3,900,000	236.80	6.1	236.49	6.1
6	9,250,000	513.85	5.5	524.86	5.7
8	16,700,000	906.20	5.4	923.49	5.5

Works Practice (*5*, page 462), using Detroit as an example.

Minimum Bills

The service charge plus the commodity rate on the functional cost basis may result in too low a bill to minimum users. Consequently, it is proposed that minimum bills be based on quantities for each size of meter, starting at 100 gpd for a ⅝-in. meter and increasing for the larger sizes in proportion to the group capacity ratios (page 210). Using the previously computed unit rates of 11.5, 7.7, and 5.25 cents per 1,000 gal and the *Manual of Water Works Practice* step limitations, the minimum bills, in round figures, would be as shown in Table 13.

Comparisons of Schedules

Schedules computed on the demand and functional cost bases are compared in Table 14. If these schedules were applied to the average quantities of water sold in Detroit through each size of meter, the average quarterly bills, including sprinkling, would correspond very closely, as shown in Table 15.

Other Alternatives

Omission of service charge. The rates previously described, whether on the demand or functional cost basis, contemplate a service charge, together with commodity rates in three steps and, if desired, minimum bills for each size of meter. Many cities, however, preferring to avoid a service charge, simplify their rate structure by employing a single minimum charge under which a minimum quantity of water is furnished, followed by the usual stepped rates. This minimum charge should be in an amount sufficient to provide the service charge plus the cost of the water furnished under the minimum charge.

Based on data previously presented, Table 16 shows how a rate structure of this type is computed. Obviously, such a rate structure must be checked against the sales records for each size of meter in order to be sure of the gross revenue. Using the approximate data available in this instance, the income is estimated as shown in Table 16. The totals of $563,600 (demand basis) and $564,400 (functional cost basis) may be compared with the figures in Table 9, which indicates a total annual cost (including sprinkling but excluding fire and air conditioning) of $561,520.

Rate to include all special uses. If, to the above rate structure, which provides for the normal service charges plus sprinkling in the minimum charge, there is added the fire charge of $107,180 (Table 9, Column 3), as well as the $94,300 in fixed charges arising out of air conditioning and refrigeration (Table 9, Column 5), the total is increased by $201,480. All of these special-use costs may be collected in the minimum charge, covering 0–9,000 gal per quarter, or else some part of them may be spread over the other steps in the schedule. If the entire amount is collected in the minimum charge—that is, apportioned equally among all meters—then the sum of $201,500 is divided by 25,807 meters, and the minimum charges are increased by $7.80 per year. The result is a minimum charge of $13.60 plus $7.80, or $21.40 per year ($5.35 per quarter), on the demand basis; and $11.10 plus $7.80, or $18.90 per year ($4.73 per quarter), on the functional cost basis. The succeeding rate steps remain the same as in Table 16. The gross revenue from such a rate, applied to the sales records, should ap-

TABLE 16
Omission of Service Charge

Item	Demand Basis	Functional Cost Basis
Computation of Charges		
*Service charge**		
Commercial expense	$50,540	$50,540
Demand charge	90,165	
Meters and services	63,180	63,180
Subtotal	$203,885	$113,720
Sprinkling charge†	84,800	84,800
Cost of water furnished (760 mil gal)‡		
At 8.2¢ per 1,000 gal	62,320	
At 11.5¢ per 1,000 gal		87,400
Total charges	$351,005	$285,920
Average per meter (divide by 25,807)		
Per year	$13.60	$11.10
Per quarter	$ 3.40	$ 2.77
Rate Structure		
Water use per quarter		
First 9,000 gal	$3.40 per quarter	$2.77 per quarter
Next 66,000 gal	8.2¢ per 1,000 gal	11.5¢ per 1,000 gal
Next 675,000 gal	5.8¢ per 1,000 gal	7.7¢ per 1,000 gal
Over 750,000 gal	4.3¢ per 1,000 gal	5.25¢ per 1,000 gal

Estimated Income

	Rate	Income	Rate	Income
Water sales				
760,000,000 gal	$13.60§	$351,000	$11.10§	$286,500
960,000,000 gal	8.2¢	78,700	11.5¢	110,000
870,000,000 gal	5.8¢	50,500	7.7¢	67,000
1,940,000,000 gal	4.3¢	83,400	5.25¢	101,900
4,350,000,000 gal		$563,600		$564,400

* See Table 10, footnotes.
† See Table 9, Column 4.
‡ Estimated use through 25,807 meters.
§ Minimum charge per year.

proximate the total expense of $763,000 shown in Table 9, Column 2.

Four Bases for Rate Structures

This section has discussed and computed rates on four bases:

1. *A demand basis* for normal users (page 207), including a service charge for each size of meter and commodity rates in three steps. The service charges are to include: all commercial expense, all costs chargeable to meters and services, and a demand charge equal to 50 per cent of the fixed costs. All special uses are to be charged separately to customers.

2. *A functional cost basis* for normal users (page 213), differing from the demand basis only in that all fixed charges are included in the commodity rates; minimum bills are based on the sum of the service charge plus the use of 9,000 gal per quarter for each equivalent ⅝-in. meter.

3. *Commodity rates only,* without a service charge, but substituting a *suitable minimum charge,* and with all special uses charged separately to customers (page 217).

4. *Commodity rates only,* without a service charge, but with a *minimum charge sufficient to provide all the costs of special uses* (page 217).

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Water Supply of Nassau, Bahamas

By Geoffrey C. Stubbs and Arthur C. Langlois

A paper presented on Oct. 12, 1953, at the Florida Section Meeting, Miami, Fla., by Geoffrey C. Stubbs, Director of Public Works, Nassau, Bahamas, and Arthur C. Langlois, Deputy Director of Public Works, Nassau, Bahamas.

THE water supply of Nassau in the Bahamas is a relatively small undertaking—less than 1 mgd *—but it has many unusual features that may be of interest. New Providence Island, on which Nassau is situated, has an area of approximately 58 sq miles. It is mainly flat, with a low ridge running generally east and west approximately ½–1 mile from the northern coast. The rock formation consists of Aeolian deposits of oolitic limestone and very hard and much weathered rock with large potholes both on the surface and in caverns underground. The rock is very porous, having 30–40 per cent voids, and holds water very well. Percolation is so rapid that no streams or brooks exist. In fact, the island can be likened to an enormous sponge, growing up from the bottom of the sea, through which the sea water penetrates, rising and falling with the tides. The rain falling on the surface eventually finds its way through the rock, and, being of a lower specific gravity, floats on top of the sea water, either depressing it through static pressure or eventually becoming absorbed by it. If the rock is too open or honeycombed, the continual movement of the tides mixes the fresh and salt waters, rendering the mixture brackish and unpotable. Where the rock is of a fine texture, however, the fresh water depresses the salt water and floats on it to form a subterranean reservoir.

Records show that the sea water is sometimes displaced to a depth of 30 ft or more below mean sea level. In general, there are no perched aquifers, and all the deposits of fresh water are found at or below mean sea level. A possible explanation of this rather curious situation in areas near the coast is that the lower specific gravity of the fresh water causes it to collect at a sufficient height above sea level so that the hydraulic gradient enables it to overcome the frictional resistance and flow off through the rock to the sea. This theory is borne out by the observation that the level of wells is much higher immediately after a heavy rainfall but returns to normal in a short time, even without pumping.

Another curious phenomenon is the presence of fresh-water areas in close proximity to regions with only brackish water. This condition is caused either by variations in the texture of the rock—both on the surface and underground—or by the presence of impervious flinty layers, usually occurring 25–30 ft below the surface, which provide a diaphragm that separates the

* Imperial gallons (equal to 1.2 US gal) used throughout.

fresh and salty water. The salinity of fresh water pumped from any area will increase if the hydrostatic balance is disturbed, and lateral seepage into any borehole must not be exceeded by the rate of withdrawal if the salinity value is not to deteriorate.

As the only source of replenishment of the underground reservoirs is rainfall, the question of estimating the amount absorbed by vegetation and evaporation is of importance in designing the drawoff from a given area. Because of the comparatively light vegetation in Nassau, it can be assumed that one-third of the rainfall percolates through the rock and is available for collection by means of wells. As the rainfall of Nassau averages 45 in. per year, the safe amount of water obtainable from an area of 100 × 100 yd is approximately 2,900 gpd. The average rate of pumping should not, therefore, exceed 120 gph. This is equivalent to 1,390 gpd per acre and assumes that the replenishment by rainfall and the drawoff are equal throughout the year, which is obviously impossible. In order to insure that the replenishment rate is not exceeded, a reduced pumping rate of 960 gpd per acre has been established. Even this rate demands rest periods if the catchment areas are not to be overpumped.

Because the ground water level remains constant owing to the hydrostatic pressure of the sea, the sea water must rise to take the place of the fresh water removed by pumping. Cones of salt or brackish water form immediately below the base of the wells and increase in height as the fresh water is pumped out. Unless the fresh water is replenished by rainfall, these cones will eventually rise to the level of the bottom of the well, and the water will become first brackish and then salt. If pumping is stopped, however, the hydrostatic pressure of the fresh water at the top and bottom of the cones will eventually cause them to level out. Thus, it is essential to rest wells even at times of abundant rainfall. In practice, it has been found better to sink many small wells in an area rather than one large one; for example, instead of using one well per acre at a rate of 80 gph, ten wells, each drawing 8 gph, should be employed on each acre.

It will be appreciated that a supply from a source such as has been described requires somewhat unusual methods of design and operation. The low rate of pumping and the large areas of catchment for a comparatively small supply of fresh water increase costs to a degree that would normally be considered uneconomical but is necessary under the circumstances.

The need for careful control of the pumping rate has been heavily stressed throughout the history of the Nassau water works. The consulting engineers who originally designed the system recommended that 34 boreholes should be used on an area of 340 acres, to enable water to be withdrawn from each well at the rate of 400 gph from every 10 acres. As the estimated consumption was then 225,000 gpd, only 26 wells would have had to be operated at one time, permitting eight to be rested. Unfortunately, in a misguided attempt at economy, only 150 acres was developed and the wells were set too close together. In addition, no reserves were provided for dry periods or for resting. The pumping rate very soon became too high, with the result that the original Blue Hills area was overpumped and never recovered from

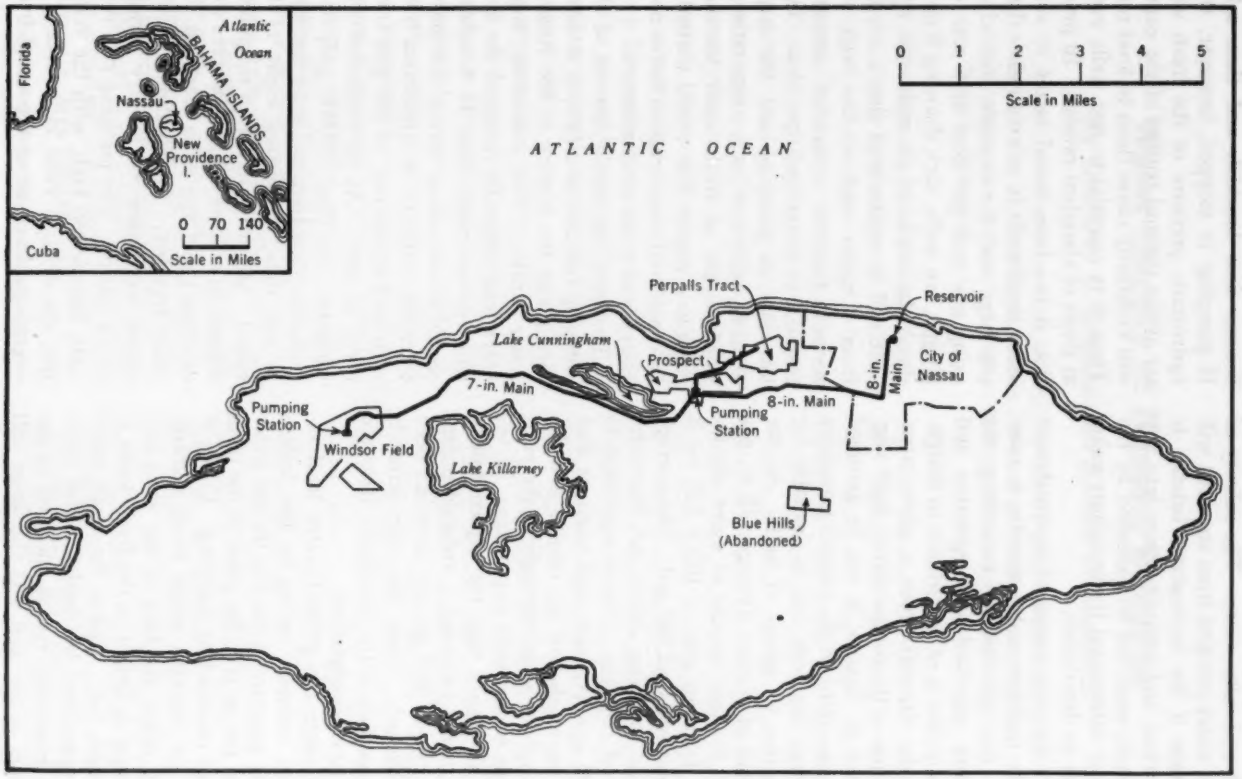

Fig. 1. New Providence Island Water Supply

this false start. It has now been abandoned, as the salinity has risen to more than 1,425 ppm.

Supply System

The present water supply system consists of three fields totaling 876 acres: Prospect, 200 acres, opened in 1938; Perpalls Tract, 200 acres, opened in 1943; and Windsor Field, 476 acres, opened in 1951. The total potential supply is approximately 0.75 mgd, while normal demand averages 0.6 mgd, with peak demands of 0.75–0.85 mgd during the height of the winter season. To produce this water requires seventeen trench systems and 268 pumps (43 electric, 4 hydraulic jet, 140 windmill, and 81 pneumatic), drawing from more than 700 wells. Prospect and Perpalls Tract are situated approximately 5 miles from Nassau and are 1½ miles apart, while Windsor Field is a further 6½ miles beyond Prospect, to which it is connected by a 7-in. cast-iron main (Fig. 1). It will be seen that the layout is far from ideal and demands an abnormally large staff for maintenance and operation.

The water is extracted from shallow wells with minimum disturbance and drawdown. Certain principles, established as a result of experience gained during 25 years of operation, are followed as closely as possible. They allow for 30 per cent extra capacity to permit adequate rest periods, 16-hr operation per day for maximum capacity, and 8-hr operation per day for average demand. Each pumping unit draws 3,000 gpd, and, by operating 300 days a year, the withdrawal approximately balances the 15 in. of annual rainfall replacement. As a general rule:

1. No borehole (4–6-in. diameter) should penetrate more than 8–10 ft of fresh water.
2. No borehole should yield more than 2 gpm.
3. No pumping unit should draw from an area of less than 160,000 sq ft or 3½ acres.
4. No shallow well pump should draw from less than four wells, and the rate should not exceed 5 gpm for 8–12 hr per day, or 3,500 gpd.
5. All wells should be equidistant around the pumping unit, to insure that each well is drawing evenly.
6. Pumping units and wells should be rested every 30 days for at least a week, to permit water levels to adjust themselves.

At Windsor Field, the latest area to be developed, these principles have been strictly adhered to. Designed to produce 0.5 mgd, the layout consists of 56 pneumatic pumping units, set out in eight lines of seven units each, supplemented by six open trenches. A few areas provide natural catchments which have been fitted with pumps and filters and produce considerable amounts of rain water during the summer. Windsor Field presently supplies 0.35 mgd, and further development is under way to provide the additional 0.15 mgd planned. Water from the wells is collected in a 200,000-gal storage reservoir, from which it is pumped through 6½ miles of pipe to Prospect and from there to the city. The raw water is chlorinated before pumping. Owing to an abnormally heavy rainfall in 1952, the salinity of the water from this area averaged as low as 155–215 ppm in 1953.

The open-trench system is popularly believed to be a simple method of obtaining water from rocky areas where

the water table is high enough to provide 3–4 ft of water in a trench 6 ft deep (Fig. 2). The water is decanted uniformly along 200 yd of trench by means of a perforated pipe set approximately 18 in. below the surface and collecting the water in a central sump. Two trenches per sump is usual, with a vertical centrifugal pump extracting the water from the sump and discharging it into the collecting main. The holes in the pipe are of varying diameter, which should theoretically result in an even collecting rate along the whole length of the trench. In practice, however, it is found that the water is drawn

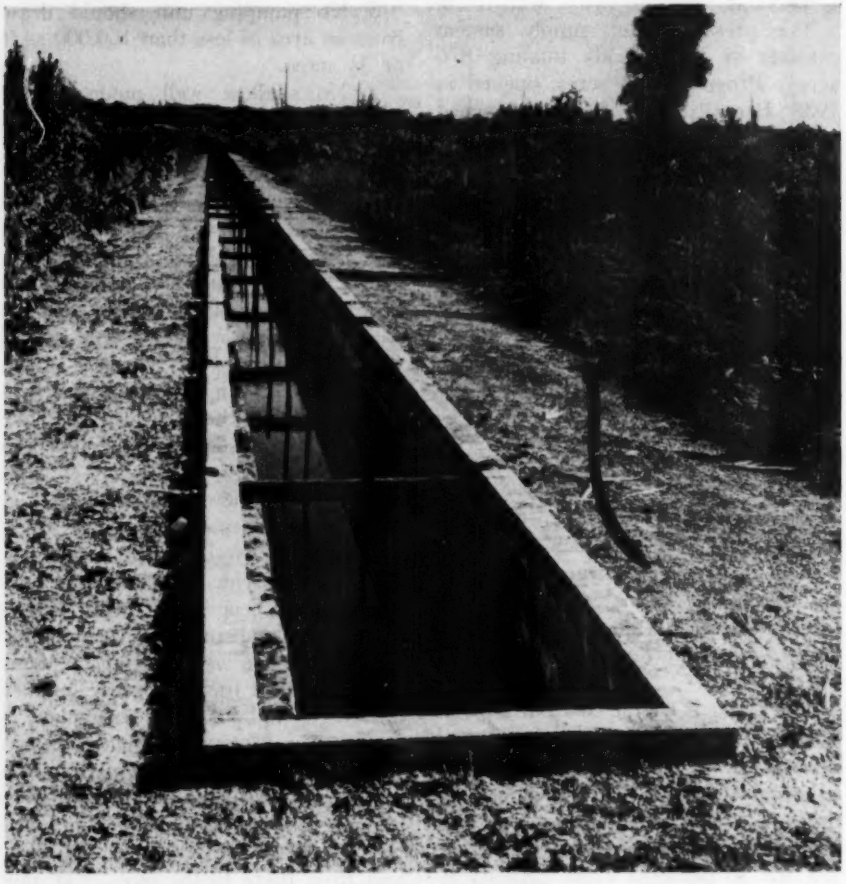

Fig. 2. Open-Trench Well

This system is used in rocky areas where the water table is high enough to provide a 3–4-ft depth of water in the trench. A collecting pipe with a small perforation every 4 ft leads into a sump, from which the water is pumped.

from the section nearest the sump at a high rate, while that at the end of the trench is barely touched. The trench system has several disadvantages: it is costly to construct; a single fault along the length of a trench may permit saline infiltration that will contaminate the whole supply; and, in spite of the apparently large amount of water available, the same inexorable limit of 960–1,000 gpd per acre of collecting area still remains. The only advantage of the system is that, in rock of close texture which prevents a quick flow of water, the trench does not draw down as rapidly as a borehole. Of course, there is also the doubtful advantage that the water level is visible.

Well Pumps

A brief description of the deep and shallow well pumps in use may be of interest. Deep well pumps usually operate a single borehole in areas along the ridge where the ground elevation is more than 20 ft above sea level. Shallow well pumps operate four wells or boreholes set radially approximately 80 ft from the pump.

Windmills

The 140 wind-powered units employed consist of towers 30 ft high with a windmill 10 ft in diameter (Fig. 3). Generally situated on high ground and spaced 200–400 ft apart, they usually operate deep well pumps. The pump has a 3-in. diameter bore and a stroke of 8 in. In low areas, the shallow well pump also has a 3-in. cylinder operating on an 8-in. stroke and draws from four wells radially disposed, 60–80 ft from the pump.

Windmills are a most reliable method of pumping, and the fickleness of the winds provides ample resting periods, so that the wells rarely turn salt-

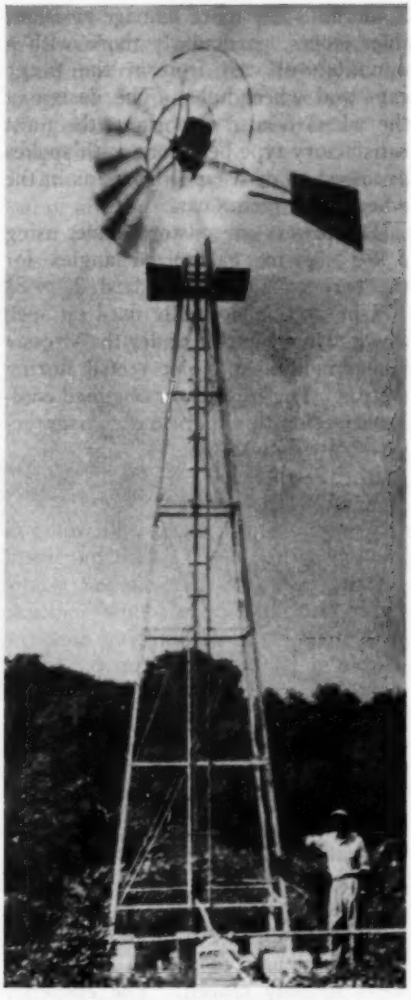

Fig. 3. Windmill Pump

The output is restricted to approximately 5 gpm by using the shortest possible stroke.

line through overpumping. Vulnerability to damage from hurricanes is their most objectionable feature. Hurricane winds with velocities of 120–150 mph can ruin vanes and tails beyond repair.

Some mills are more damage resistant than others, particularly those with a minimum of cast iron in the tower caps and wheel hubs. The design of the wheel is also important, the most satisfactory type being one with spokes arranged to withstand thrust, as in the wheels of a racing car.

The towers are custom made, using $3 \times 3 \times \frac{3}{16}$-in. galvanized angles for the corners. (The standard $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{8}$-in. section normally used on such towers would buckle under the stress.) The windmills are not reefed during storms. The free power obtained compensates for the hurricane damage occasionally suffered.

Hydraulic Jet Pumps

The objection to deep well windmill pumps is that the usual arrangement permits only one borehole per pump. Where it is desirable to use multiple deep wells with one pumping unit, the hydraulic jet pump has proved effective. In one instance, where the lift is 65 ft, four very small jet units are employed, one per borehole. The main driving or pumping unit is a nominal 2-hp centrifugal pump, and the output is approximately 20 gpm. This is an unusually high rate, but the water table is excellent, and no trouble has been experienced after 5 years of operation.

It is possible for a large centrifugal pump to be used to operate 12–15 deep wells suitably spaced. The efficiency is low, but the practical advantage of a high lift with only one prime mover is considerable. Pumps are usually reliable and trouble free, and can operate with a discharge head of 60 ft.

Pneumatic Pumps

The common air-lift pump has been used for many years. Although a model of simplicity, it is not entirely satisfactory, as it requires too much submersion in order to get sufficient lift. Discharging into a collecting main requires low hydraulic gradients and little or no static head. A number of double lifts have been made possible by means of an additional well which is provided with an overflow into the main well. By careful adjustment, the system will function for long periods without attention. Under suitable conditions, the air-lift pump has given good service for years. Its output is limited to 200–250 gph over an 8-hr day.

The quantity of compressed air required for a 16-ft lift and a 14–15-ft discharge is approximately 0.65 cu ft of free air per Imperial gallon. The efficiency is undoubtedly low but the cost of operation and maintenance is equally so. The transmission of compressed air at low pressures (about 15 psi) requires careful attention to pipe diameters, but distances of 3,000 ft from the compressor have presented no difficulties. At one time, 90 air-lift pumps were operated, with 50 being activated simultaneously from a compressor of 144-cu ft capacity, or approximately 3 cfm per air-lift pump.

To keep a number of air-lift pumps in adjustment requires the air pressure to be reasonably stable. Changes of water level and other factors causing variation of pressure must be constantly watched and the necessary adjustments made. The compressor is kept working close to capacity without unloading. Owing to the shallow operating depth of 12–16 ft, the use of compressed air at 50 psi is expensive and not too satisfactory. Lower pressures, 12–14 psi, have proved more reliable for sustained output and adjustment.

Ejector pumps (Fig. 4) are preferred to other pneumatic types because they are able to draw up water at a distance from a depth of 14 ft and will discharge against a 60-ft head. They normally operate four radially disposed wells, set 80 ft from the pump and discharged into a collecting main of ample dimensions. The adjustments are simple, but a minimum air pressure of 30–35 psi is required to work the ejector efficiently. A vacuum created inside the tank permits an intake of approximately 7 gal of water. A float rises with the water and operates the compressed-air valves, which provide the necessary pressure to discharge the contents of the tank into the main. The complete filling and discharging cycle is set at 1½ min, yielding an average of 5 gpm for an average consumption of 1.1 cu ft of free air per Imperial gallon.

The air-lift pump is more economical of air, as it is submerged and needs none for filling, but the ejector pump is free from mechanical troubles, needs no priming, and operates with a minimum of attention for months at a time.

A large part of the compressed air is used by the ejector pump in creating suction. An attempt was made to reduce this waste of air by eliminating the ejector and filling the tank by

Fig. 4. Ejector Pump

This pneumatic pump normally operates four radially disposed wells.

means of four very small air-lift units. The internal modifications for such an arrangement were very simple. When the pump has only the forcing of the water to perform, a one-third saving in compressed air is possible, with only 0.72 cu ft of free air per gallon being required.

The use of compressed air, even through a network of pipes as much as 4 miles long, has proved simpler in operation and maintenance than the electrically powered systems, which are susceptible to breakdowns, vulnerable to hurricane damage, and affected by a shortage of skilled electricians.

Electric Pumps

A total of 43 electrically operated piston type pumps, with a $2\frac{1}{2} \times 3$-in. stroke, are in use in the Prospect and Perpalls areas. These pumps, geared down to yield approximately 280 gph, have 0.75-hp, 550-v, 60-cycle motors. The choice of 550 v is the result of the need to locate the pumps at least 400 ft apart and to cover the requirements of 20–30 pumps from one transformer. These conditions require relatively high voltages to offset the inevitable voltage drop at the ends of the lines. With one transformer at 550 v, approximately 80 acres can be provided with pumps without undue loss of electrical efficiency. As usual, each pumping unit draws from four wells set radially 60–80 ft away from the pump. Electric pumps are more efficient than the pneumatic types but have a number of disadvantages, as previously mentioned.

Operational Problems

The operation and maintenance of the Nassau water supply is far from being free of difficulties. Fluctuations in well levels due to tides, lack of rainfall replenishment in the dry season, and other reasons cause the efficiency of the pneumatic pumps to vary almost alarmingly at times. Air is wasted and pressures drop below operational levels. Electrical failures are inevitable, and long spells without wind cause anxiety when the 140 windmills fail to produce their quota. A reserve of 3 mil gal is of some assistance, but, as the dry season is also the period of greatest demand, it is often difficult to replenish the reserve when it is most necessary. Therefore, a large staff must maintain constant vigilance except during very wet spells.

To safeguard against overpumping of wells, with a consequent increase in salinity, daily tests are made for salt content. The entire system is checked for salinity at regular intervals, and salinity contours are plotted to indicate incipient failure.

Samples of water are taken regularly throughout the system for bacteriological testing by the government analyst. Fortunately, because of the natural filtration of the water through the limestone beds and the prohibition of cattle and sheep grazing on the catchment areas, the water supplied has always met a high standard of purity. It is regrettable that, prior to the development of Windsor Field, the water from the older areas had so increased in salinity that the taste had become objectionable to visitors, a situation which gave rise to rumors that Nassau water was bad. With the operation of the new field, however, the average salinity of the water has been reduced to less than 200 ppm. Visitors now make fewer complaints, but some of the local people consider the water too flat. (Who would be a water engineer?)

Supply and Demand

As no detailed survey of the island's water supply has been carried out, it is not possible to state accurately the total potential supply of fresh water, but from available information the following facts are known. In addition to the present 0.75-mgd capacity, 450 acres at Windsor Field is available for future development, and an estimated 1,000 acres of good water-bearing land in the western part of the island could be either purchased or otherwise acquired. The known reserve is, therefore, 1,450 acres, capable of supplying 1.1 mgd. Thus, the total potential public supply of fresh water is 1.85 mgd. Water from presently unexplored areas may raise this figure to 2 mgd. There are, of course, many private wells that provide water for individual household use, but these, although of great value in reducing the demand on the public supply, could not be incorporated in it. In addition, a large proportion of the rainfall in built-up areas is collected in water tanks, the construction of which is enforced for all new buildings with a floor area of more than 750 sq ft.

Water is supplied to consumers through 3,300 service connections and a large number of public standpipes that provide approximately 25 mil gal a year free to the poorer inhabitants. The demand rose from 60.75 mil gal per year in 1932 to 212 mil gal in 1952. Although the number of water services has increased at a fairly regular rate, the demand has been affected by so many extraneous circumstances—including the influx of the Royal Air Force during the war years and the postwar building boom—that it is difficult to forecast the future with any degree of certainty.

Taking into account all the known factors—the proposed new hotels, the average yearly increase in the past, the high water rates, and the generally improved standards of living of the lower-paid colored population—it is reasonable to assume that the demand for water will double in the next 20 years and will amount to over 400 mil gal per year by 1970. After that, it is not anticipated that it will increase very much unless changed methods of production have been introduced. Consequently, it would appear that, provided the water department's organization is suitably expanded to meet growing demands as they occur, no serious water famine need be feared. The situation will not, however, be entirely satisfactory, because plentiful supplies of fresh water for industrial purposes will be lacking and, if the present methods of production are continued, the cost of water will remain high.

It is evident that the large number of pumps, the great quantity of piping required to connect the widespread wells, and the additional staff needed to operate and service them raise the cost per 1,000 gal to a figure well above that which consumers consider reasonable in places where the water supply can be obtained by more usual means. In 1952 the average cost of producing and distributing water in Nassau was 82 cents per 1,000 gal. Of this amount, 48.5 cents was for actual production, 25 cents for distribution, and 8.5 cents for semirecurrent expenses and administration.

The only way in which these costs could be substantially reduced would be by a large increase in the amount of water produced, as distribution and overhead charges remain fairly constant. This step could not be taken until additional areas were developed, because there would be a very serious

danger of overpumping existing supplies and ruining the water-bearing areas beyond repair, as was done with the Blue Hills supply. Also, the waste of the island's supply of fresh water is highly undesirable.

Water Rates

The need to prevent waste and reduce demand was severely felt in the late 1940's before the development of the Windsor Field area. In order to achieve this end, a sliding scale of charges for water was introduced in the middle of 1949. Under this scheme, residential rates increase as consumption rises, the first 1,000 gal per week being charged at the lowest rate, the second at a slightly higher rate, and all above that at a much higher one. Water for commercial purposes, however, remains on a flat-rate basis. This rate applies mainly to hotels and apartment houses.

The effect of the new schedule was most marked, and the demand fell by 15 mil gal in 1949. In 1950 the rates were raised slightly to cover rising costs, and a further 14-mil gal reduction in demand resulted. Although the demand has now risen above the 1949 figure, this is due mainly to the new services connected. Nassau consumers are still very waste conscious. This reversal of the usual commercial practice of "the more you use, the less you pay" does not lower the cost of production, but it certainly did help to tide over the difficult period before the completion of the Windsor Field development and it does curtail capital expansion.

Desalting

The real solution to the island's water supply problems would appear to be the introduction of some method of desalting either brackish or sea water at a sufficiently low rate to permit unrestricted use of fresh water by everyone, domestic and commercial consumer alike. Almost unlimited supplies of brackish water with a salinity of 2,000–4,000 ppm are available, and it would not seem too optimistic to hope that some method will be evolved within the next 10 years or so to desalt this type of water at a reasonable cost. Meanwhile it will be necessary to continue to produce water by the present interesting, but relatively inefficient, methods.

Cutting Pipe in Place

By Oscar G. Goldman

A paper presented on Oct. 29, 1953, at the California Section Meeting, San Francisco, Calif., by Oscar G. Goldman, Supt., Distr. Div., Water Dept., San Francisco, Calif.

WHEN the author first began his career as a water works engineer, a number of years ago, one of his many duties was supervision of the repairing of leaks and breaks, as well as the laying of new mains and their connection to the existing lines. The most exasperating part of the entire work was the cutting and removal of portions of the existing pipelines.

The method of cutting pipe in place was extremely slow, tedious, and uncertain. Almost always, whether the purpose of the cut was to repair a break or to make a connection, a section of the distribution system had to be shut down, thus leaving a number of consumers without water, as well as creating a fire hazard. The longer the shutdown period, the greater was the wrath of the consuming public.

Despite careful planning to minimize the period of shutdown, many failures occurred, resulting in excessive delays in restoring service. The author had many such experiences, but one in particular led to near disaster. As the pressure in the main involved was extremely low, all the work of preparation was done in advance of the actual shutdown, which would affect a large residential and light commercial area. It had been planned to complete the work by 5:00 AM, but service to the district was actually not resumed until 10:30 AM. The consequent public reaction can well be imagined.

This failure was due to the fact that the bottom 3 ft of pipe circumference had not been properly prepared; it had not been grooved. The blame belonged to the author, because he did not personally inspect the work and merely took the laborer's word.

Until rather recently, most distribution system water mains 4 in. and larger were made of unlined cast iron. Today most of the cast-iron pipe, up to and including 16 in., is cement lined. In the last few years asbestos-cement pipe has been adopted in some distribution systems, particularly in small communities and in the outlying areas of large cities.

Former Cutting Methods

At the time of the incident described —approximately 28 years ago—the method of cutting cast-iron pipe in the trench involved the use of a diamond-faced hardy and a 12-lb sledge hammer. The hardy was held at a slight angle to the side of the pipe, by means of a short wooden handle, and was then struck with the hammer (Fig. 1). This method of cutting, though slow, produced the required results for the upper two-thirds of the circumference of the pipe; for the bottom third, the method was the same, except that a small hand hardy and hand hammer were used.

Three roundabout cuts were made: two close together, and the third at the

required distance from the first. Then the sledge hammer again came into play, this time in order to break out or destroy the pipe between the cuts (Fig. 2), starting with the smaller section first.

If the cuts were of the proper depth, that is, almost through the entire thickness of the pipe, the destroyed pipe

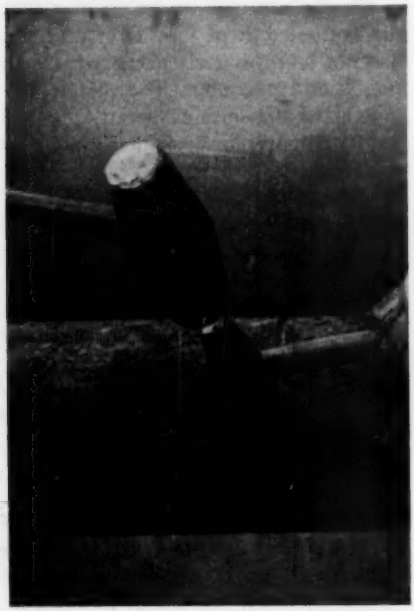

Fig. 1. Hardy and Sledge Hammer

The diamond-faced hardy is held at a slight angle to the pipe.

remained within the limits of the cuts; otherwise the pipe would crack beyond the desired limits. When that occurred, it became necessary either to make another roundabout cut or, more often, to destroy the entire length of pipe between bells.

The use of the hand hammer and hardy to make the cut around the bottom third of the pipe circumference required a wide and deep hole, so that the men could lie on their side or back to get at the work. If such a hole could not be dug because the subsoil was rock or because there were other underground utility structures close by, the cuts were made as far around the pipe circumference as possible, in the hope that, when the pipe was cracked, the break would follow the line of the cut all the way around. For that purpose, chisels would be driven into one of the cuts. Sometimes the

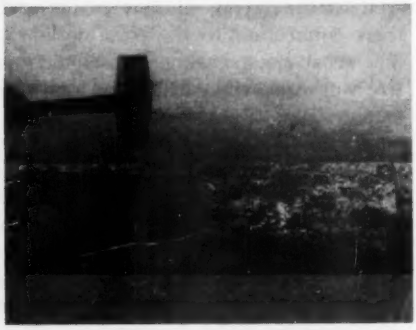

Fig. 2. Destruction of Pipe

After the circumferential cuts have been made, the pipe is broken with the sledge hammer.

method worked, but it often failed. In the latter event, the only thing to do was to utilize all the sledge hammers available to break up the entire length of pipe between bells. Even when no difficulties were encountered, many hours were required for cutting the pipe by means of hardies.

Recent Advances

In recent years a manually operated multiple-wheel cutter (Fig. 3) has been developed. This device has done

away with the hardy, but the sledge hammer is still a very useful tool, especially for the destruction of the pipe section between cuts. One of the principal difficulties with the multiple-wheel cutter is that the wheels do not always track, each one tending to make a separate cut. When this occurs, a new circumferential cut must be attempted.

Fig. 3. Multiple-Wheel Cutter

A 90-deg rotation of this manually operated cutter is sufficient to cut the entire circumference of the pipe.

As before, three roundabout cuts are made, and the pipe section between cuts must be destroyed with sledge hammers. On the large-diameter pipes, the cutting is slow and tedious, because only light cuts can be made, owing to the manpower needed to rotate the cutter.

The room required for operating the multiple-wheel cutter is somewhat less than that for the hardy and sledge hammer, particularly at the bottom of the pipe. The cutter completely surrounds the pipe and a 90-deg rotation is sufficient to cut the entire circumference. The pressure on the cutter is maintained by means of a screw in the handle. The rotating of the cutter is continued until a crack is produced in the roundabout cut.

Fig. 4. Three-Wheel Cutter

This cutter must be revolved through a 180-deg angle and requires a wider trench than the multiple-wheel cutter.

For small cast-iron pipe, a standard three-wheel cutter (Fig. 4) is used. This type requires a wider trench than

the multiple-wheel cutter, as it must be revolved through an angle of at least 180 deg. This tool is also operated until a crack is produced in the roundabout.

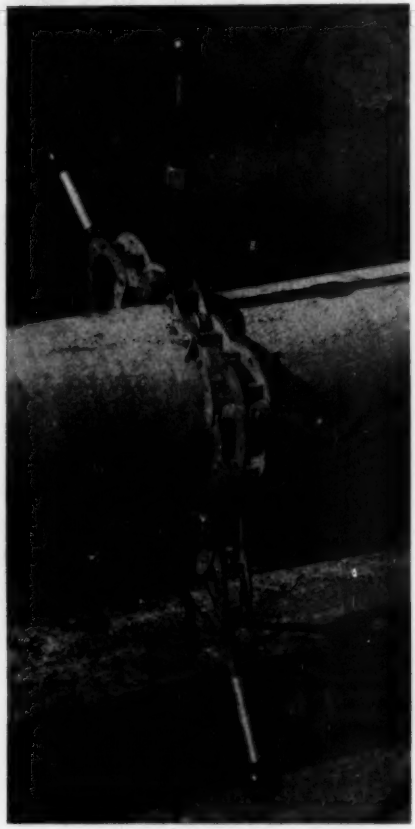

Fig. 5. Asbestos-Cement Pipe Cutter

The single cutting tool is rotated around the pipe by means of the handles.

One of the more recent developments in the art of cutting cast-iron pipe is the use of an electric arc, in combination with a controlled flow of oxygen. The metal is melted and burned along the line of the desired cut. If there is an appreciable flow of water in the pipe owing to a leaky gate valve, bypassing is necessary before the cut can be completed. The electric-arc method, which is used on the large-diameter pipe, has a number of disadvantages: it is slow and tedious; the work is hard and time consuming; the cut is wide and ragged; and a deep, broad trench is required.

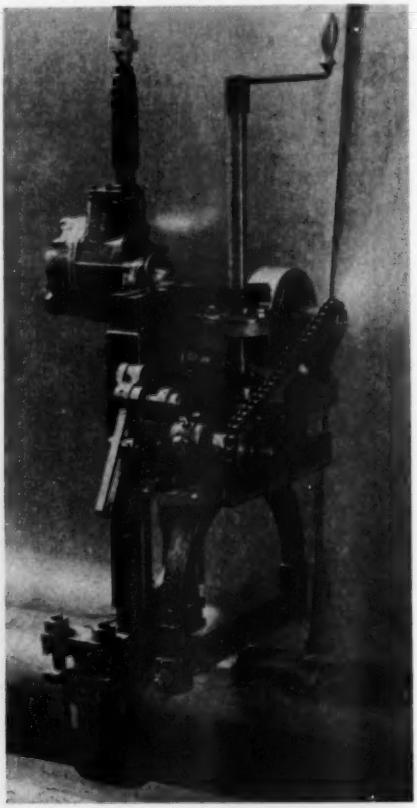

Fig. 6. Cutting Machine

This newly developed machine (patent applied for) cuts across the pipe rather than around it.

Although the cutting of asbestos-cement pipe is relatively simple and easy, it, too, presents a problem. The material is soft enough for an ordinary carpenter's saw to be used, but the cement destroys the effectiveness of the saw after a few cuts. In some instances, hacksaw blades have been used with better results.

A special tool has been developed for cutting asbestos-cement pipe. This device is held on the pipe by specially constructed links with rollers (Fig. 5). The single cutting tool is rotated around the pipe by means of handles, the feed for the cutting tool being through one of them. To get sufficient power for the rotation of the cutter, the handles must be of considerable length.

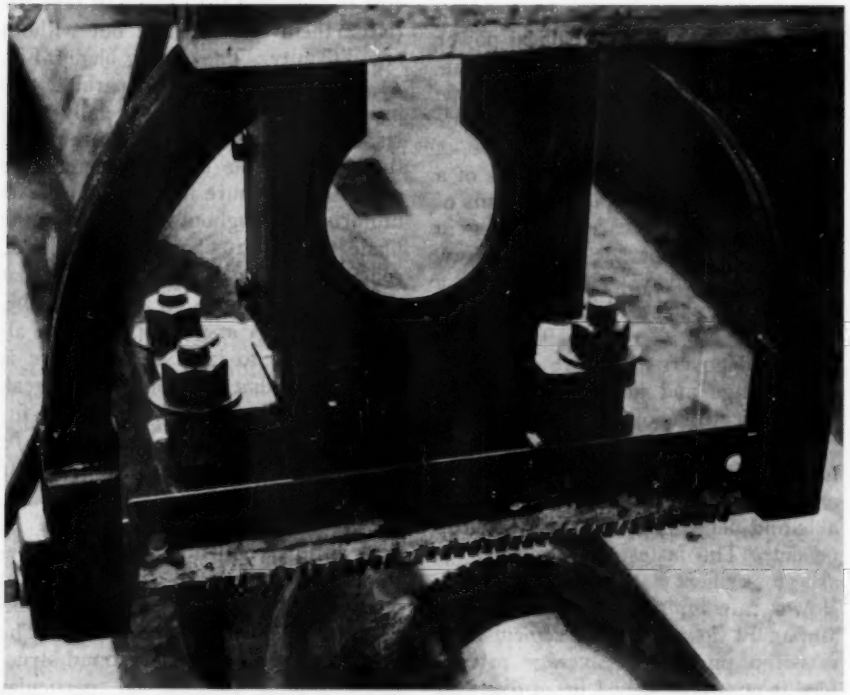

Fig. 7. Cutting Blade

The blade (patent applied for) consists of cemented carbide tips brazed into a specially constructed steel blank.

In order to cut asbestos-cement pipe in place by any of the methods mentioned, the trench must be very wide and deep, which may prove costly in heavy soils. Sledge hammers are not used, however, because the pipe sections between cuts are not destroyed but lifted out.

New Cutting Machine

Within the past year a new, portable cutting machine has been developed which, it appears, will eliminate all of the previous uncertainties and delays. It does away with one of the roundabout cuts in cast-iron pipe and also with the destruction of the pipe between cuts. It substitutes mechanical power for manpower, and, with the proper attachments, can be operated by any type of power available—engine, electric, or compressed air.

The machine (Fig. 6) consists of a stand fastened to the pipe by means of a flexible chain; a carriage sliding in the guides of the stand; and a hacksaw type blade and yoke fastened to a crosshead moving within the guides of the carriage. The movement of the crosshead governs the rate of feed to the carriage and also determines the length of stroke of the cutting blade.

The machine is set at right angles to the pipe and cuts across it, not around it. The rate of feed is adjustable and depends upon the material to be cut. The fastest feed is used for asbestos-cement pipe, with a slightly slower rate for unlined cast-iron pipe and a still slower feed for cement-lined cast-iron pipe. The average rate of feed is approximately 1 in. of diameter per minute for cast-iron pipe and 2 ipm for asbestos-cement pipe.

Almost any pipe can be cut in the trench with this machine, because the travel of the cutting blade is only 2 in., and a 4-in. clearance on each side of the pipe is all that is required. If the machine can be set up on a piece of pipe, it can be successfully cut.

The cuts made by the machine are, for all practical purposes, square to the axis of the pipe. The width of the cuts is such that the section of pipe between them can be lifted out without any difficulty. The cutting blade (Fig. 7) consists of cemented carbide tips brazed into or on a specially constructed steel blank. In assembling the tips with the blank, care must be exercised to insure that each tip is set uniformly throughout the length of the blade; that all tips have the same rake, relief, and side clearance; and that their cutting edge is on a straight line.

As the cuts in the pipeline are always square to its axis and there is no danger that the pipe will break beyond the limits of the cuts, the fittings to be inserted in the gap can be assembled well in advance of their installation.

With this machine, there will be very little pavement removal and replacement; likewise, only a slight amount of extra excavation and backfill, if any, will be required. The proximity of other underground structures should present no particular problem. Pipe sections formerly destroyed can be saved and reused. Finally, the period of shutdown of the system can be reduced to an absolute minimum.

Results of Research on Sulfur Jointing Compounds

By Raymond B. Seymour, Walter R. Pascoe, and Robert H. Steiner

A contribution to the Journal by Raymond B. Seymour, Pres.; Walter R. Pascoe, Asst. Lab. Director; and Robert H. Steiner, Research Director; all of Atlas Mineral Products Co., Mertztown, Pa. *This paper is published for the information of the water works field, and neither it nor the discussion that follows it is to be considered an official opinion of AWWA.*

IT has been shown previously (*1*) that plasticized sulfur cements possess adequate physical properties for use as capping materials for concrete test specimens. Additional investigations (*2*) have shown that plasticized sulfur compound specimens poured at 130°–150°C possess optimum strength, stiffness, and ductility, and that these properties are not affected adversely by repeated or prolonged melting and heating of the material. As a result, it may be stated quite conclusively that, based on fairly extensive physical tests, plasticized sulfur cements have sufficient strength and ductility to justify their use as jointing materials for bell-and-spigot cast-iron water mains.

Another requirement of jointing materials, in addition to adequate physical properties, is that they should not contribute to corrosion problems characteristic of cast-iron pipe. Previous investigations on tuberculation, the deleterious action of sulfate-reducing spirilla (*Desulfavibrio desulfuricans*), graphitization, iron bacteria (*Gallionella ferruginea*), and scale formation through iron rust have been reviewed by Kuhr (*3*). He stated that cast-iron pipe is predestined to contain cathodic and anodic areas that must lead to tubercle formation. All evidence to date indicates that materials used to join pipe do not contribute to tubercle formation.

Elemental sulfur, in the presence of moisture, is known to be corrosive to steel (*4*), but commercial plasticized sulfur cements have been shown to be many times less corrosive under the same test conditions (*5*, *6*). Actually, plasticized sulfur cements are widely used to protect steel from corrosion (*7*, *8*). Although there is an initial reaction between sulfur cements and cast-iron or steel surfaces, this action is not progressive.

Other investigations have shown that cast iron or steel completely embedded in a plasticized sulfur cement is not attacked after long immersion in water (*9*). Although cast-iron pipe has been joined successfully with sulfur cements for more than 30 years (*10*), difficulty in some specific localities has caused concern.

Most of the failures in sulfur cement joints have been associated with disintegration. Some engineers (*11*) have

suggested that this phenomenon is bacterial in nature, but Frederick and Starkey (*12*) considered this postulate an inadequate explanation. They also showed that *Thiobacillus thiooxidans* would not attack sulfur cements containing small amounts of bactericides such as sodium silicofluoride. The formula developed in the authors' laboratory (the "Atlas" formula) and made available to all manufacturers of sulfur cements contains this ingredient (*13*).

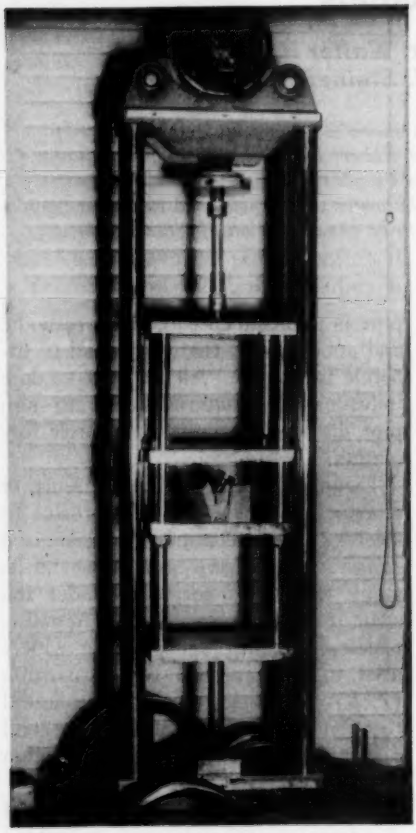

Fig. 1. Penetration Test

A force of 900 lb broke the unplasticized sulfur cement cube with less than ⅛-in. penetration.

Stress-Strain Studies

Breaks in water mains cause property damage and are costly to repair. Such breaks are apparently characteristic of nonductile metals and may occur in pipe joined not only with sulfur cements but also with Portland cement, and in pipe with lead and mechanical joints as well. Many water works engineers and metallurgists are cognizant of this problem (*14, 15*).

TABLE 1

Physical Requirements for Plasticized Sulfur Cement

Characteristic	Quantity	Reference ASTM Designation
Tensile strength—*psi*	300–450	C190
Compressive strength—*psi*	3,000–4,500	C26, C109
Modulus of rupture—*psi*	600–1,100	
Resistance of aggregate to settling (max. variation from unity)	0.2	C287
Proportion of residual strength retained after thermal shock test—*per cent* (*min.*)	50	
Specific gravity	1.95–2.25	
Moisture absorption—*per cent* (*max.*)	1	C287
Ductility*—*lb*	200–750	

* As measured by the minimum force required for penetration of a ¼-in. diameter rod to a depth of ½ in.

Extensive investigations with SR-4 strain gages have shown plasticized sulfur compound joints to be strain free (*13*), but, in spite of the soundness of the techniques used, such measurements are not well understood by all water works engineers. Simpler ways to show that plasticized sulfur compound pipe joints are strain free have been found (*16*), although these methods are not completely conclusive. It

was, therefore, necessary to develop conclusive strain tests as readily understandable as those which show that salt-free plasticized sulfur joints do not disintegrate or contribute to the corrosion of cast-iron pipe (*6*, *13*).

Stress-strain measurements have shown unplasticized sulfur cement to be essentially a nonductile material. This assertion may be verified by simple observation of the fracture that takes place when attempts are made to force a small rod into compositions of this type. On the other hand, a highly plasticized sulfur cement accepts the rod and does not fracture readily. Simple modifications of this qualitative technique produce a quantitative measurement.

If attempts are made, by means of a gradual increase in pressure, to force a $\frac{1}{8}$-in. diameter rod into the surface of a sulfur cement block, reproducible measurements for depth of penetration and applied force can be obtained. As shown in Fig. 1, the rod penetrates less than $\frac{1}{8}$ in. and the cement fractures when a force of approximately 900 lb is applied to a 2-in. cube cast from an unplasticized, filled sulfur cement.

In contrast, a commercial plasticized sulfur cement used for joining soil pipe was penetrated to a depth of $\frac{3}{8}$ in. by a force of 700 lb before any fracture occurred. A commercial cement used for joining cast-iron mains was penetrated to a depth of $\frac{3}{8}$ in. by a force of only 600 lb without any subsequent fracture. A more highly plasticized sulfur cement used as a component of a triple-layer chemical-resistant lining (*17*) was penetrated $\frac{3}{8}$ in. by a force of less than 200 lb.

Because a much larger amount of plasticizer than that used for the component of the triple-layer acid-proof membrane can be employed, the maximum ductility of a commercial plasticized sulfur cement is limited primarily by the application for which it is intended. Ductility and compression or tensile strength are inversely related. Consequently, federal (*18*) and ASTM (*19*) specification requirements of 500-psi and 400-psi tensile strengths, respectively, inadvertently place low ceilings on the ductility of sulfur cements.

Based on present knowledge and experience, the ideal sulfur cement for joining cast-iron pipe should meet the following specifications:

Component	Amount *per cent*
Sulfur	55 –65
Graded silica and other additives	35 –45
Carbon	0.5– 4
Plasticizer	0.5– 5
Sodium silicofluoride	0.6

Physical Requirements

Plasticized sulfur cement should conform to the physical requirements listed in Table 1 when tested 48 hr and 1 year after casting test specimens. It is difficult to imagine that a product as ductile as this material could cause a rupture in a cast-iron pipe having a tensile strength exceeding 10,000 psi. If specifications for greater ductility are established, they can be met readily, provided the tensile- and compressive-strength requirements are lowered proportionately.

Regardless of what ductility value is considered adequate, the permanence of this value is of the utmost importance. Investigations have shown that sulfur can be plasticized to produce cements exhibiting no appreciable change in ductility during long periods of standing. As might be expected, there is a small change in both tensile strength and ductility during the first

few weeks, but no further changes have been observed over protracted periods.

Moreover, all tests indicate that this property of ductility in a plasticized sulfur cement joint is retained under service conditions. Spectrographic tests on plasticized sulfur cement joints after 15 years of service have shown the joints to be free from iron, except for a small characteristic zone at the interface. These observations have also been confirmed qualitatively on pipe joints after 25 years of service.

The effect of plasticization in preventing breakage of the joint itself has also been demonstrated. When disks or rings of plasticized sulfur cement are poured in a quart glass canning jar, a glass cylinder, or a large beaker, no breakage of glass or compound occurs, nor is any change noted after long standing in air or under water. As shown in Fig. 2, unplasticized sulfur cements shrink sufficiently on cooling to permit the glass cylinder molds to separate, whereas the plasticized specimen on the left exhibits no radial shrinkage. Figure 3 illustrates the condition of a plasticized sulfur joint, poured between glass surfaces, after being under water for more than a year.

Fig. 2. Shrinkage Characteristics

The three unplasticized specimens at right have shrunk sufficiently to permit the glass cylinder molds to slip down. The plasticized specimen at left exhibits no radial shrinkage.

In another simple test, slots to a depth of at least two-thirds the thickness were cut in cross-sectional rings from commercial cast-iron pipe. Molten sulfur cement compositions were poured as disks and as joints between concentric slotted rings made from pipe of different diameters. The simulated weakened joints were immersed in a fresh-water stream for a year and inspected periodically. In every instance, fractures in the unplasticized

sulfur cements were noted in a short time, but no cracking or shrinkage was observed in any of the samples with plasticized sulfur cements. It is of interest that, although few additives produce true ductility when mixed with sulfur cements, at least ten different compounds will plasticize sulfur cements sufficiently to prevent cracking

Fig. 3. Effect of Long-Term Immersion

No cracks have appeared in the cement or beaker after more than a year under water.

and shrinking when large rings are cast from them.

A notched iron ring, in which sulfur cement containing 1 per cent sodium chloride had been poured, cracked after less than 7 months' immersion. Another notched iron ring, separated from a similar but smaller one by sulfur cement containing 3 per cent iron filings, cracked after a year's immersion. It should be noted that, under the conditions of test, the iron was badly rusted and the slots were filled to a large extent by rust. These conditions, which are not normal for a joint in a water line, may have contributed somewhat to the breaking of the slotted iron rings. Nevertheless, it is significant that such failures did not occur with plasticized sulfur cements after more than a year of exposure.

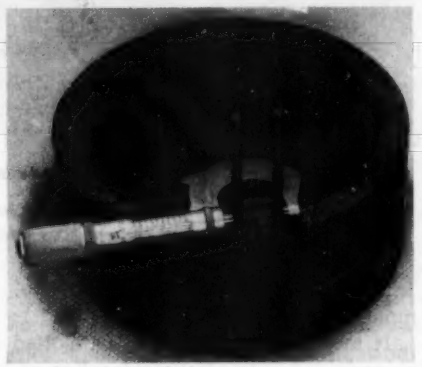

Fig. 4. Measuring Movement of Slot

The distance between the pins indicates how far the split has moved in a given length of time.

In a similar series of tests, caps with slots to a depth of at least two-thirds of the pipe wall were placed on 2-in. cast-iron soil pipe. The annular space between the pipe and the cap was filled with molten sulfur cement, and the 5-ft length was placed in a vertical position and immersed in water. Observations made during the course of a year showed no tendency for the caps to crack when joined with plasticized sulfur cement, although a joint made from unplasticized sulfur cement containing

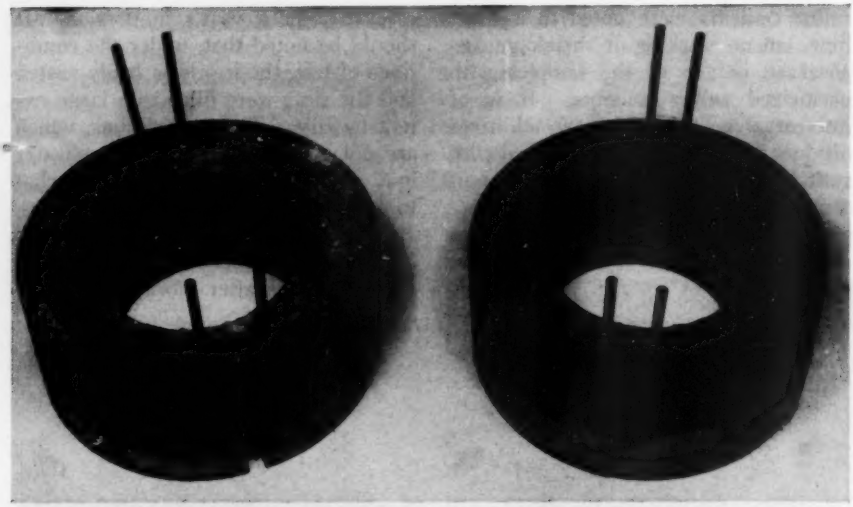

Fig. 5. Effect of Cement Composition on Movement of Slot

The split ring at left was joined with unplasticized sulfur cement containing salt. Plasticized cement was used in the split ring at right.

1 per cent salt cracked open after 4 months of test.

It might be argued that the slotted rings joined with plasticized sulfur cement may also have been under a small amount of strain, although not sufficient to break the ring. This possibility should not be disregarded, because additional stresses from water hammer or street traffic might rupture a pipe already under a small amount of stress at the joint. To investigate this aspect, another study made use of rings that were completely split. The movement of the split with time was measured by means of pins placed above the slot, as shown in Fig. 4. Concentric 4-in. and 6-in. cast-iron pipe sections were used in these experiments. The annular space was filled with molten sulfur cement, and any movement of the outer ring was measured after immersion in water for various intervals at room temperature.

Table 2 indicates that, in the control samples and in those rings joined with Portland cement or lead, the movement was no greater than 3 mils during the period of test. When an unplasticized sulfur cement was used, however, a 31-mil movement of the slot was observed after 18 weeks' immersion. In contrast, the movement of rings joined with sulfur cements containing various amounts of plasticizer was 9 mils or less after 18 weeks' immersion. Typical specimens after immersion are shown in Fig. 5.

The maximum movement noted with plasticized sulfur cements is of insufficient magnitude to be attributable to stress from the jointing material. As in the tests in which the more accurate SR-4 strain gage techniques were used, it may be concluded that plasti-

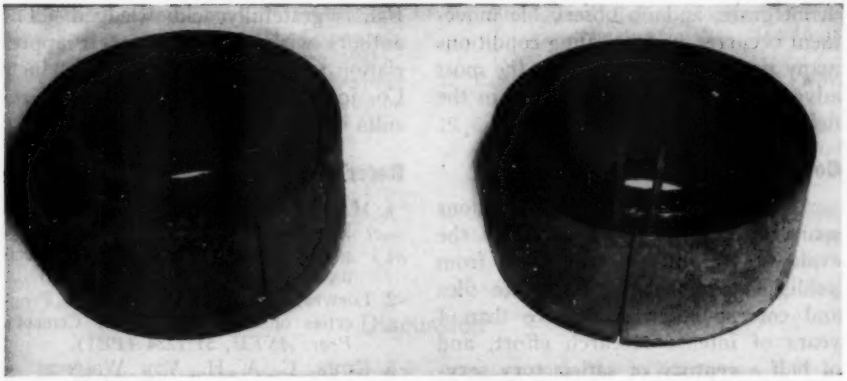

Fig. 6. Effect of Poorly Made Joint

Cloth was embedded in the plasticized cement used in both specimens. No excessive movement resulted.

cized sulfur cements do not contribute to stress when used as joints in cast-iron pipe.

No background data are available to permit conclusions on this point for the unplasticized sulfur cement joints. It would probably not be sound judgment, however, to disregard a movement ten times that of the rings which did not contain a jointing material or were joined with lead or Portland cement. As shown in Table 2, when sulfur cement containing 1 per cent salt was used to join the rings, the movement was greater than 250 mils after 10 weeks.

Admittedly, the data proving that plasticized sulfur cements do not contribute to strain were secured from tests made under laboratory conditions. Therefore, it was considered desirable to determine the effect under more adverse conditions, such as might be expected if the coal-tar coating were not removed from the surfaces to be joined or if the joints were prepared improperly. No excessive movement of the outer ring was noted when the surfaces of the rings were heavily coated with coal-tar pitch before making the joint, or when the sealing of the joint was prevented by placing heavy cloth between the iron surfaces and the sulfur cement (Fig. 6). In the latter experiment, the formation of iron sulfide was not limited to the thin section customarily observed but extended through a major part of the joint. Even so, there was no tendency for the joint to

TABLE 2

*Movement of Slotted Rings**

Jointing Material	Immersion Period *weeks*	Movement *mils*
4-in. control ring	18	3
6-in. control ring	18	3
Concrete	18	1
Lead	18	0.5
Plasticized sulfur cement *A*	18	2
Plasticized sulfur cement *B*	18	6
Plasticized sulfur cement *C*	18	9
Unplasticized sulfur cement	18	31
Unplasticized sulfur cement (with 1% sodium chloride)	10	over 250
Plasticized cement (coal-tar coated ring)	6	1
Cloth embedded in plasticized cement	12	5
Cloth embedded in plasticized cement	12	2

* Temperature range, 68°–74°F.

disintegrate, and no observable movement occurred under sealing conditions many times more severe than the most adverse that might be expected in the field.

Conclusions

As a result of practical observations spanning more than 20 years, of the evaluation of all available data from published literature and private files and correspondence, of more than 4 years of intense research effort, and of half a century of satisfactory service in pipelines, the following conclusions appear justified:

1. Sulfur cement joints made in accordance with the previously published (*13*) "Atlas" formula do not disintegrate under conditions anticipated in a water line.

2. Sulfur cement joints containing a minimum amount of bactericide are not attacked by sulfur bacteria.

3. Although sulfur joints seal by an initial reaction at the cast-iron interface, this action is not progressive if the sulfur cements are made in accordance with the "Atlas" formula.

4. Because of their inherent ductility, plasticized sulfur cements do not contribute to stress within a pipe joint. As highly plasticized compositions are available, there is essentially no limit to the degree of ductility that can be secured with a plasticized sulfur cement.

Acknowledgment

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Discussion

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This report by Seymour, Pascoe, and Steiner consists largely of a review of the published literature on sulfur cements used for joining cast-iron water pipe. Many of the claims made in this paper are considerably more general than those in a 1951 JOURNAL article (*1*) by the same authors and others. The present paper offers very few new data to substantiate these broader claims. The only additional data consist of further tests made to demonstrate the stress-producing tendencies of certain sulfur cements with and without plasticizer and soluble salt additions.

Corrosion

Although the validity of the data given in this and previous papers is not questioned, many of the authors' conclusions are difficult to accept in view of field experiences investigated by the writer's firm and others, and also in the light of certain data and conclusions presented in earlier work by the authors. The authors do not discuss field experiences with corrosion of metal surfaces, disintegration of sulfur cements, or pipe bell failures. Although it is agreed that the number of instances in which joint failures have been suspected of being due to sulfur jointing compounds is statistically minor in comparison to the wide use of these materials, such a situation does occur occasionally. However infrequent, to the water works operator concerned, it is a serious condition. No attempt is made by the authors to explain these failures.

The authors make the point that all evidence to date indicates that jointing materials do not contribute to tubercle formation in cast-iron water mains. The discussion of tuberculation in this paper and any attempt to associate the use of sulfur cement with the tuberculation problem are misleading, and conclusions drawn from such a discussion have no bearing on the corrosion of sulfur compound joints.

Investigation of a number of installations where troubles have occurred in sulfur-jointed water pipelines has shown that considerable corrosion pitting has occurred at the iron-sulfur interface, both on the inside of the bell and on the outside surface of the spigot. Corrosion pits 150 mils or more in depth have developed within a few

years at the sulfur-iron interface, while the surface of the pipe exposed to the soil within a few inches of the joint showed no measurable corrosion, indicating that the soil environment was relatively noncorrosive. Files maintained by the writer's firm list a number of instances in which quite serious corrosion has taken place at the sulfur-iron interface. It appears, therefore, that sulfur cements have contributed significantly to the corrosion of cast-iron pipe joints.

Seymour and others have stated elsewhere (*1*) that sulfur cements should not be used in cast-iron pipe under conditions that are corrosive to cast iron itself, nor should they be used if the pH of the water or surrounding soil is greater than 9. In another paper (*2*), Seymour and colleagues noted that iron nails partially embedded in sulfur cement showed corrosion at the iron-sulfur interface and that the presence of electrolytes, either in the sulfur cement or in the surrounding water, accelerated both the corrosion and cracking tendencies. These statements indicate that the authors have evidence that sulfur cements can and do contribute to the corrosion of cast iron and other ferrous metals under certain conditions. The observations pertaining to completely embedded iron nails lack importance as evidence, for it is recognized that corrosion will not occur unless an electrolyte is present. Unfortunately, moisture can be present at the sulfur-iron interface of a poorly made joint.

In view of the above objections, the authors' discussion of corrosion in cast-iron water mains is of no consequence and is irrelevant to the real problem of corrosion at the iron-sulfur interface of joints. That problem does exist.

Breakage

Breaks in pipelines joined with sulfur cements have been reported by several water works operators, and some instances have been investigated by the writer's firm and others. The breaks seem to occur in two patterns: circumferential breakage of the spigot directly adjacent to the joint and longitudinal splitting of the bell.

In spigot failures, the pipe has been found to be seriously weakened by a band of deep corrosion encircling the pipe at that point on the spigot where the first contact is made with the sulfur cement. This develops a circumferential notch, and the breakage failure is believed to be due to the concentration of external bending stress in the weakened notched section.

Where bells have failed by splitting longitudinally, there is usually evidence of severe corrosive attack on the iron adjacent to the jointing material. Although the loss of metal will weaken the bell considerably, this fact alone is not usually sufficient to account for the splitting of the bell. Tests conducted a number of years ago demonstrated that certain of the sulfur cements made into joints in which the metal thickness was reduced would develop sufficient stress in the metal to cause it to split after short periods of immersion in water and soil.

Considerable improvement has undoubtedly been made in the formulation of sulfur cements by the use of plasticizers, but similar failures continue to occur in pipe installed as recently as 1941. The paper under discussion contains further data on the stress-producing characteristics of sulfur cements, both with and without plasticizer addition, indicating the ben-

eficial effect of plasticizer. The authors do not, however, attempt to explain the field failures of pipe joints. They mention examinations and tests made on plasticized sulfur joints after 15 and 25 years of service, implying that the employment of a plasticizer is not a recent development and that its commercial use predates by many years the installation of sulfur cement joints in pipelines now encountering joint failures due to bell splitting.

Stress-Strain Studies

The authors' discussion of stress-strain studies tends to become confusing as they initially take the position that cast iron is a nonductile metal and then describe SR–4 strain gage tests made on cast-iron pipe to demonstrate that no strain is produced in the metal by the sulfur cement. If cast iron were nonductile, the SR–4 gage would not show any strain prior to failure, because no movement could take place. Cast iron does have ductility, however, and the authors' statements to the contrary are inaccurate.

In reference to the authors' proposed specifications for sulfur cement, it is noted that rather wide limits are placed on the amount of plasticizer to be used and the range of ductility to be obtained. Yet, in the data presented on the effect of plasticizer on ductility and stress development in sulfur cement joints, practically no information is offered on the amount or type of plasticizer used for these tests. If stress development is a function of the ductility of the cement, data showing the correlation of stress development, ductility, and amount and type of plasticizer are needed to support the proposed specifications.

An examination of the data in Table 2 raises a number of questions. In studying the amount of movement of split rings containing various materials, it is reported that the control rings and those containing concrete and lead jointing materials showed movements of 0.5–3 mils in 18 weeks. Plasticized sulfur cement *A* also fell within this range, but plasticized sulfur cements *B* and *C* showed 6 and 9 mils, respectively. The unplasticized material showed 31 mils of movement. These data are of no help unless the amount and type of material used as a plasticizer are known. It is obvious that there are significant differences in the three plasticized cements, but the authors refer repeatedly to plasticized cement without qualification as producing a strain-free joint. In the conclusions it is stated flatly that "plasticized sulfur cements do not contribute to stress within a pipe joint." The data presented do not substantiate such statements, as Table 2 clearly indicates that different strain-producing characteristics can be obtained by varying the plasticizer addition.

The authors have reported that unplasticized sulfur cements have caused the failure of simulated weakened joints after short periods of immersion in water and that this material has produced 31 mils of movement in 18 weeks. It could easily be that plasticized sulfur cement *C* would also produce sufficient strain to cause failures in reasonable periods of time. Work done at the writer's laboratory has shown that sulfur cement claimed to contain plasticizer has produced cracking after very short periods. Where this particular material would fit in Table 2 is unknown, but the test results certainly point to the need for

more specific information on plasticizer additions.

The data reported in Table 2 on the ring coated with coal-tar pitch substantiate findings at the writer's laboratory, where the use of a coating inside $\frac{1}{8}$-in. thick cast-iron rings afforded considerable protection from corrosion at the iron-sulfur interface. The time of failure due to internal stress, which was about a month for uncoated rings, was extended to more than 3 years for coated rings.

Conclusion

It is believed that the work done by the authors to date has considerably advanced the state of knowledge pertaining to the properties of sulfur cements. It is still felt that certain weaknesses noted in field service have been insufficiently investigated and that adequate data have not been presented to substantiate many of the claims made in this report. Before a satisfactory specification for sulfur cement can be prepared, additional data are necessary, in order to define more clearly the relationship of stress development, ductility, and plasticizer content.

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Water Resources Inventory and Development

By Edward B. Rice

A paper presented on Nov. 9, 1953, at the North Carolina Section Meeting, High Point, N.C., by Edward B. Rice, Dist. Engr., US Geological Survey, Raleigh, N.C.

THE uses of water for municipal and industrial purposes are so varied and the demands are growing so rapidly that it is becoming more and more difficult to forecast future needs. An adequate program for the collection of stream flow data permits reliable estimates of potential supplies to be made.

Basically, the conditions responsible for the failure of water supplies to meet requirements are: [1] inadequate design and planning of water-consuming processing equipment; [2] failure or inability to use available salt water in place of fresh water; [3] water wastage; [4] withdrawal of water from underground aquifers in excess of natural recharge; [5] overconcentration of population and industries; [6] selection of sites for development without adequate evaluation of availability of water for existing or predictable future requirements; and [7] failure to provide for equalization of surface water runoff.

Considerable research is being carried on to make salt water sources more adaptable to various uses. More and better information is available on water use. Improved techniques have been developed for appraising future demands and for the reuse of water—for example, the use of the sewage effluent from Baltimore, Md., in the Sparrows Point steel mill. (It is reported that water in streams carrying domestic sewage has been reused as many as six times before becoming too highly concentrated with sodium salts.) All of these measures are contributing to the reduction of recurring water shortages, but more needs to be done. A more comprehensive program for maintaining an inventory of stream runoff and collecting data on variations of flow is particularly desirable.

It would be a rare occurrence if the supply and demand on a stream system were to balance over an appreciable period of time. Because of the characteristic variations in stream flow, together with the variations in demand for water from a stream system, there generally results a wide variation in the ratio of supply to demand. Where this demand exceeds the supply even for a day, some form of storage is necessary to assure that water demands can always be met. The size of the storage facilities is governed by the volume of and the variations in flow as related to variations in demand. As larger and larger reservoirs become necessary, economic considerations and losses from evaporation and seepage rise in importance. Water losses from storage reservoirs, even in the humid East, may amount to as much as 20 per cent of the total runoff. Silting is also a governing factor in reservoir design.

The annual runoff represents the total flow of a stream and the upper limit of all water potentially available for development. Consequently, this figure forms a convenient unit or base for many hydrologic investigations. With

few exceptions, river basin developments requiring quantities of water greater than the average annual runoff must rely on water diverted from other basins to provide the excess. Annual, seasonal, and local variations in runoff are associated with corresponding variations in precipitation. It is most important, therefore, that facts bearing on this relationship be gathered wherever there is a present or even a contemplated water use.

Stream flow, which is measured at an established point such as a gaging station, may be expressed in cubic feet per second, acre-feet, or inches depth over the drainage area above the station. It should be recognized that this figure is not necessarily uniform throughout the basin but may vary from place to place because of differences in precipitation or in geologic or topographic characteristics.

Available hydrologic data do not conclusively indicate a trend toward drier or wetter periods. There is a virtual certainty, however, that drought conditions are not permanent and will be followed by years of abundant rainfall. Despite these periodic variations, the total available water from all sources is more or less constant over the years. It is readily apparent, therefore, that the ever growing demand will eventually approach the maximum potential supply.

As development increases to such an extent that water supplies are being utilized to their maximum capacity, disputes over water rights become numerous. Many states have set up codes and regulatory measures to govern the use of water within their boundaries. This is universally true in the arid West and is spreading eastward as developments exhaust the available supplies. The use of interstate waters has been the subject of compacts and court actions. The need for adequate data in connection with these problems was brought out in a case before the US Supreme Court dealing with the proposed diversion of waters from the Delaware River for use in New York City. In his report, the special master in the case stated:

> There was a vast volume of evidence accompanied by numerous exhibits as to the effect of the proposed New York diversion on the Delaware River. In determining this effect the parties necessarily resorted in the main to the same basic data. The most reliable information obtainable consisted of the stream flow records of the gaging stations of the United States Geological Survey and some state records.
>
> In determining what the effect of the New York diversion would be in the future, the parties attempted to show what the probable effect of the New York diversion would have been if it had existed in the past. The stream flow records of the Delaware River do not exist for any long period of time. It would have been much more satisfactory if complete stream flow records had been available for a number of points on the Delaware River for a period, say, of 50 years.

It should be emphasized that runoff is exceedingly variable and has a highly complex relationship to climate, geology, topography, and vegetative cover. The chances of increasing water supplies or making present supplies secure depend largely on an understanding of the factors that influence runoff.

It is important to know the amount of runoff in a given region because this figure represents the total supply of water available for use. Runoff records demonstrate that, through intelligent design and use, streams can continue to be dependable sources of supply.

Calculation of Impounded-Storage Requirements

By Charles Smallwood Jr., Herbert B. Wyndham, and Daniel N. Cote

A paper presented on Nov. 9, 1953, at the North Carolina Section Meeting, High Point, N.C., by Charles Smallwood Jr., Assoc. Prof. of Civ. Eng.; Herbert B. Wyndham, Graduate Student; and Daniel N. Cote, Graduate Student; all of North Carolina State College, Raleigh, N.C.

THE widespread failure of impounding reservoirs to sustain cities during the recent drought across the nation is sufficient reason for presenting once again a tried and proved method of calculating storage requirements. Allen Hazen first published an extensive analysis of storage computation in 1914 (*1*) and later generalized a vast quantity of data in a few tables (*2*). It is appropriate to recall some of the general features of the analysis employed by Hazen in this important contribution to professional knowledge.

A commonly used technique of determining storage requirements is to examine the driest period on record for the stream to be regulated and then to provide sufficient storage to maintain the desired draft. This method, however, produces an insufficient requirement when the available record does not contain a serious drought period, and an excessive requirement when the record includes an unusually severe drought which might be expected to occur only once a century. The essence of the method advanced by Hazen was to study the frequency of droughts and select a storage figure that would be adequate in perhaps 19 years out of 20.

An illustration of the frequency method of design may be drawn from the authors' study of the Neuse River in North Carolina. The gaging station record selected for analysis was that for Clayton, N.C., where the drainage basin is 1,140 sq miles in area and the river has a mean annual flow of 0.71 mgd per square mile, based on a 19-year period of record (*3*). The cumulated flow was plotted for the entire period, although only a portion of the graph is shown in Fig. 1. As the ordinate represents the volume of water and the abscissa the time, the slope of the curve at any point indicates the rate of flow at that particular time.

On the plot of the cumulative flow, slopes are established to represent any desired draft or any desired percentage of the mean annual flow (percentage of utilization). The slope of the draft curve is transferred to the cumulative curve wherever a point of tangency exists, as shown in Fig. 1. Over a given length of time, the maximum ordinate between the cumulative curve and the draft curve depicts the volume of stor-

age required during the low-flow period to maintain the draft desired. One such storage value is selected for each water year, even though in some years the value may be zero. In Table 1 nineteen storage values (for the years 1927–45) are shown for two degrees of utilization. Translated into different units, it is seen that the values range from 26 to 206 days' storage at 100 per cent utilization.

TABLE 1

Annual Deficiencies

(Neuse River at Clayton, N.C.)

Year	Deficiency—*mil gal/sq mile*	
	100% Utilization	50% Utilization
1927	42.70	0.44
1928	36.90	10.10
1929	18.53	6.70
1930	117.70	32.10
1931	63.80	22.40
1932	146.50	34.70
1933	134.70	50.80
1934	29.40	7.70
1935	85.10	16.00
1936	39.45	4.81
1937	32.05	5.60
1938	52.80	13.20
1939	45.30	9.34
1940	48.10	14.70
1941	121.20	43.00
1942	58.70	13.60
1943	114.30	42.70
1944	53.40	13.10
1945	49.70	5.34

In Table 2, the storage values are arranged in order of increasing magnitude. As no value is repeated, each may be assigned a frequency of one, indicating that, in the 19 years of record, a particular storage value occurred only once. The cumulative frequency indicates the number of times a given value was not exceeded.

It is then assumed that the frequency with which any particular storage value would occur in an infinite number of years would follow the normal error law, and, consequently, if such values

TABLE 2

Cumulative Frequency Distribution

Storage *mil gal/sq mile*	Frequency	Cumulative Frequency	Plot Percentage $\frac{100m}{n+1}$
50 per cent Utilization			
0.44	1	1	5
4.81	1	2	10
5.34	1	3	15
5.60	1	4	20
6.70	1	5	25
7.70	1	6	30
9.34	1	7	35
10.10	1	8	40
13.10	1	9	45
13.20	1	10	50
13.60	1	11	55
14.70	1	12	60
16.00	1	13	65
22.40	1	14	70
32.10	1	15	75
34.70	1	16	80
42.70	1	17	85
43.00	1	18	90
50.80	1	19	95
100 per cent Utilization			
18.53	1	1	5
29.40	1	2	10
32.05	1	3	15
36.90	1	4	20
39.45	1	5	25
42.70	1	6	30
45.30	1	7	35
48.10	1	8	40
49.70	1	9	45
52.80	1	10	50
53.40	1	11	55
58.70	1	12	60
63.80	1	13	65
85.10	1	14	70
114.30	1	15	75
117.70	1	16	80
121.20	1	17	85
134.70	1	18	90
146.50	1	19	95

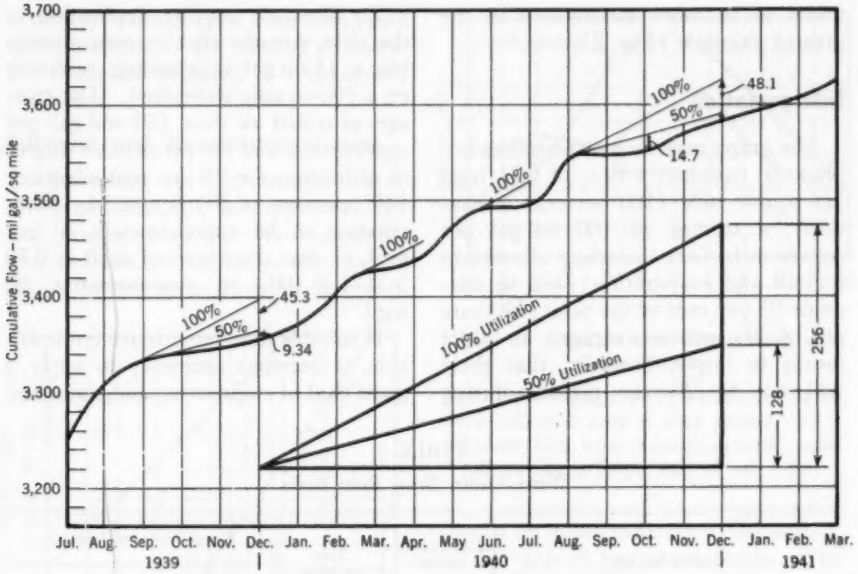

Fig. 1. Determination of Storage Requirements

The upper curve shows the cumulative flow of the Neuse River at Clayton, N.C., for a portion of the period of record. The slope representing the desired percentage utilization is the hypotenuse of a right triangle the other two sides of which represent flow and time. For example, the mean annual flow in the drainage basin under study is 0.71 mgd per square mile; 100 per cent utilization would amount to 0.71 × 365 = 256 mil gal per square mile per year; the values 256 (mil gal) and 12 (months) are therefore laid off and the hypotenuse is drawn. Parallels are then constructed tangent to the cumulative-flow curve. The largest ordinate segment intercepted by the curve and any tangent during a given period represents the maximum deficiency in that period and, hence, the amount of storage required.

are plotted on probability paper (*1*), they should lie on a straight line. The plotting position of each term in the series may be determined in one of two ways, to avoid the statement that the storage required will always be less than a given value. Hazen suggested that the plotting position, P, of the mth term in a series of n terms be determined by the center-of-strip method, using the formula:

$$P = \frac{(2m - 1)}{2n}$$

Other authors (*4*) have used:

$$P = \frac{m}{n + 1}; \quad P(\%) = \frac{100m}{n + 1}$$

and have noted little difference in the final results. The latter equation was employed in the present analysis.

It is sometimes found that data plotted arithmetically on probability paper do not adhere closely to the straight line indicated by the normal error law, but, if plotted logarithmically, will fit quite well. A logarithmic plot was

found to be more satisfactory in the present example (Fig. 2).

Interpretation

The graph may be interpreted as follows: to maintain a flow of 0.71 mgd per square mile (100 per cent utilization), a storage of 160 mil gal per square mile (not including allowances for silt and evaporation) will be adequate 95 per cent of the time (19 years out of 20), on the average. It is not meant to imply, however, that there will not be 20-year periods during which this amount of storage will fall short in more than one year.

Suppose that the data presented are applicable to a town requiring 35.5 mgd from a 100-sq mile drainage basin that yields 0.71 mgd per square mile. This 50 per cent utilization of the mean annual flow would require storage amounting to 58 mil gal per square mile, or a total of 5.8 bil gal, to insure an adequate supply in 19 years out of 20.

To illustrate another application of the data, assume that a town already has a 15-bil gal impounding reservoir on a 100-sq mile watershed. The storage provided is then 150 mil gal per square mile, and the permissible degree of utilization for 95 per cent adequacy (19 years out of 20) is found by interpolation to be approximately 70 per cent, so that the expected draft is 0.70 × 0.71 × 100, or approximately 50 mgd.

If suitable flow records are not available, it becomes necessary to apply a great deal of engineering judgment and to examine carefully the records for all streams in the vicinity of the design stream. Table 3 shows the means and extremes for streams in the Neuse Basin. The average yields found from longer periods of record are slightly higher than those from shorter periods. The larger areas also show more stability and less variation than the smaller ones. Thus, in transferring the results of the Neuse study to a small drainage basin, very optimistic figures would be

TABLE 3

Water Yields, Neuse River Basin

Gaging Station	Duration of Record *yr*	Area *sq miles*	Water Yield—*mgd/sq mile*		
			Max.	Avg	Min.
Contentnea, at Hookerton	17	789	1.49	0.64	0.34
Contentnea, at Wilson	15	236	1.18	0.68	0.33
Dial Creek, at Bahama	4	4.9	1.01	0.55	0.23
Eno River, at Hillsboro	16	66.5	1.08	0.68	0.25
Flat River, at Bahama	20	150	1.03	0.64	0.24
Little River, at Princeton	14	229	1.33	0.74	0.41
Middle Creek, at Clayton	6	80.7	0.95	0.72	0.22
Neuse River, at Clayton	19	1,140	1.15	0.71	0.34
Neuse River, at Goldsboro	15	2,370	1.29	0.68	0.38
Neuse River, at Kinston	15	2,690	1.29	0.69	0.39

obtained. Hazen (*1, 2*) has broadened the application of the method of analysis by the introduction of a variability coefficient.

Siltation and Evaporation Losses

Allowances for siltation and evaporation are absolute necessities in current design practice. The magnitude of the allowance is difficult to arrive at except by reference to experience with basins that have been in operation for considerable periods. Brown (*5*) has collected available information on siltation losses and a portion of his data is included in Table 4. The application of the data may be shown for the Lake Johnson Reservoir of the Raleigh, N.C., water supply. The drainage basin is only 6.8 sq miles and the storage provided, based on a 1923 survey, should be approximately 1,530 acre-ft, or 225 acre-ft per square mile. The loss of storage to be expected from siltation should range between 0.1 and 0.65 per cent per year, with a mean loss of 0.31 per cent per year. In 1951, North Carolina State College determined the actual storage to be 1,365 acre-ft, representing a loss of approximately 0.59 per cent per year. As a substantial portion of the watershed is unprotected by adequate grass or forest, the loss in storage is in good agreement with the data offered by Brown.

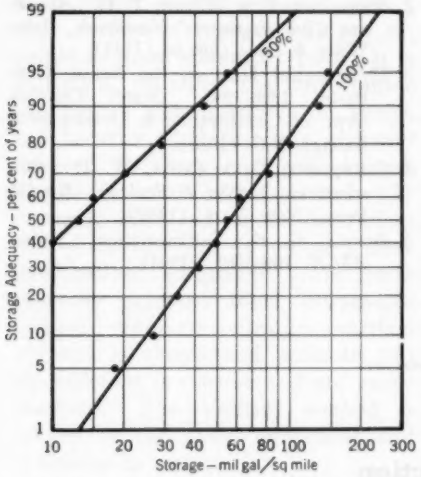

Fig. 2. Adequacy of Storage

The curves indicate the percentage of years a particular amount of storage will be adequate, with either 50 or 100 per cent utilization.

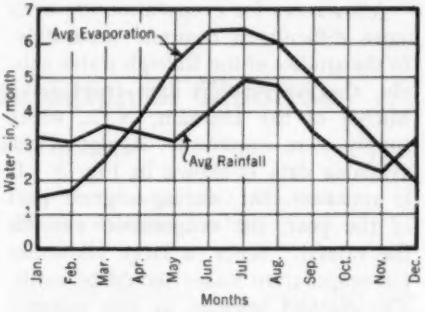

Fig. 3. Rainfall and Evaporation at Lake Michie

The data on which these curves are based were collected over a long period. It is apparent that evaporation exceeds rainfall during a large part of the year.

TABLE 4

*Expected Storage Losses From Siltation**

Original Storage *acre-ft/sq mile*	Annual Storage Loss—*per cent*		
	Min.	Max.	Avg
1– 25	0.52	6.09	2.82
26– 50	0.78	2.09	1.34
51– 75	0.36	1.06	0.73
76–200	0.04	1.04	0.42
more than 200	0.10	0.65	0.31

* Data from Brown (*5*) for southeastern states.

Allowances for evaporation are even more difficult to compute accurately. In the studies of the Raleigh water supply, the evaporation data from Lake Michie of the Durham, N.C., water supply were employed. A plot of the available data is shown in Fig. 3. It is apparent that, during a great part of the year, the evaporation exceeds the rainfall; hence, a large allowance for evaporation losses should be made. The method selected in this instance was simply to integrate the area between the rainfall and evaporation curves during the part of the year when evaporation exceeded the rainfall. It would be more appropriate, however, to select a particularly dry year for this allowance.

No attempt has been made by the authors to do more than present an old and well established method of determining storage requirements. It is hoped that this exposition of underlying principles may benefit those who do not have ready access to the original paper by Hazen.

References

1. HAZEN, ALLEN. Storage to Be Provided in Impounding Reservoirs for Municipal Water Supply. *Trans. ASCE*, **77**: 1539 (1914).
2. MERRIMAN, T. & WIGGIN, T. H. *American Civil Engineers' Handbook*. John Wiley & Sons (5th ed., 1941).
3. Hydrological Data on the Neuse River Basin, 1866–1945. North Carolina Dept. of Conservation & Development, Raleigh, N.C. (1950).
4. JOHNSTONE, D. & CROSS, W. P. *Elements of Applied Hydrology*. Ronald Press, New York (1949).
5. BROWN, C. B. Sedimentation. *Trans. ASCE*, **109**:1085 (1944).

Correction

The final two of the three formulas at the bottom of the last page of the "Tentative Standard Specifications for Sodium Pyrosulfite" (January 1954 JOURNAL, page 96) should read:

$$\frac{\text{ml } 0.1N \text{ iodine soln.} \times 0.3203}{\text{weight of sample}} = \text{per cent } SO_2$$

$$\frac{\text{ml } 0.1N \text{ iodine soln.} \times 0.4753}{\text{weight of sample}} = \text{per cent } Na_2S_2O_5$$

The formulas as printed in the January issue are correct if both the iodine and thiosulfate solutions used are exactly $0.1N$. When, as usually happens, the solutions are not adjusted to exact normality, the first of the three formulas shown on page 96 can be employed to find "ml $0.1N$ iodine soln." This value may then be substituted in either of the equations given above.

Mercurimetric Determination of Chloride

By Jerome F. Thomas

A contribution to the Journal by Jerome F. Thomas, Asst. Research Chemist, San. Eng. Research Lab., Univ. of California, Berkeley, Calif.

IN the operation of water and waste treatment plants, personnel with a wide variety of backgrounds are required to make laboratory tests. It is important, therefore, that any routine quantitative determination be simple and accurate, and that any endpoint involved be sharp and well defined. The Mohr and Volhard methods (*1*) currently employed for the determination of chloride ions do not meet these specifications adequately. The more generally accepted silver nitrate–potassium chromate titration method (Mohr) is simple and accurate, but the endpoint is evasive and not easily observed. The Volhard method is subject to the same limitations and is tedious as well.

This paper presents a simple method, new to the field of sanitary engineering, that has the desired sharp and well defined endpoint. Good replication of results by this method indicates a high degree of precision, and comparison with the Mohr method shows the proposed technique to be reliable.

The method, which is similar to several others described elsewhere (*2–4*), involves the mercurimetric titration of chloride ions, utilizing mercuric nitrate as the titrant and diphenylcarbazone as the indicator. A solution containing mercuric ion is added to a solution containing chloride ion to form soluble mercuric chloride. The ionization of mercuric chloride is so slight that free mercuric ions appear in the solution only after an excess of mercuric ion has been added. A purple coloration, which a small concentration of mercuric ion gives with diphenylcarbazone, furnishes the means of detecting the endpoint.

Procedure

The mercurimetric chloride test can be conducted with standard equipment available in a water or waste treatment plant laboratory. The reagents used are:

1. *Sodium chloride stock solution, 1,000 ppm of chloride ion.* Prepared by dissolving 1.648 g of reagent grade sodium chloride (dried 1 hr at 600°C) in distilled water to a final volume of 1 liter.

2. *Mercuric nitrate solution, approximately 0.0141*N. Prepared by dissolving 2.52 g of $Hg(NO_3)_2 \cdot H_2O$ in approximately 20 ml of distilled water acidified with approximately 0.25 ml of concentrated nitric acid. The acidified mercuric nitrate solution is diluted with distilled water to a final volume of 1 liter. The solution is filtered, if necessary, and standardized against 10-ml aliquots of the stock sodium chloride solution; 1 ml of the mercuric nitrate solution is approximately equivalent to 10 ppm of chloride ion. In standardizing, the only variation from the pro-

cedure later described for water samples is the adjustment of the initial pH with a more dilute nitric acid solution (0.02*N*). The standardized solution is known to be stable for at least 4 months.

3. *Diphenylcarbazone – bromphenol blue mixed indicator.* Prepared by dissolving 0.5 g of cp crystalline diphenylcarbazone and 0.05 g of bromphenol blue in 95 per cent ethyl alcohol to a final volume of 100 ml. Prolonged storage is possible in a brown bottle.

4. *Nitric acid, approximately 0.2N.* Prepared by diluting 12.7 ml of cp nitric acid (sp gr 1.42) with distilled water to a final volume of 1 liter.

5. *Hydrogen peroxide, 30 per cent.*

6. *Aluminum hydroxide suspension.* Prepared by dissolving 125 g of potassium or ammonium alum in 1 liter of distilled water. Precipitate the aluminum by adding ammonium hydroxide slowly while stirring. Wash the precipitate by successive decantation of distilled water to free it of chloride ion.

If samples are turbid or colored, clarification is necessary prior to chloride determination. The technique of clarification is the same as that used in accepted methods for chloride determination (*1*). To the measured water sample, a small quantity of the aluminum hydroxide suspension is added. The mixture is gently swirled for approximately 10 min, preferably on some mechanical device. Filtration or centrifugation results in a solution sufficiently clear for analysis of the chloride ion.

To perform the analysis, measure a clear water sample, containing not more than 20 mg of chloride ion, into an Erlenmeyer flask and dilute, if necessary, with distilled water to a final volume of 100 ml. Add ten drops of the mixed indicator solution; if an orange-violet color develops, the pH

TABLE 1

Standard Chloride Samples

Sample No.	Chloride Present—*mg/100 ml*											
	0.25		1.0		2.5		5.0		10.0		20.0	
	Chloride Found—*mg/100 ml*											
	*A**	*B*†	*A**	*B*†	*A**	*B*†	*A**	*B*†	*A**	*B*†	*A**	*B*†
1	0.32	0.24	1.06	0.99	2.49	2.50	5.06	4.98	10.00	10.01	20.16	20.04
2	0.27	0.24	1.01	0.99	2.51	2.49	5.11	5.01	10.04	10.00	20.01	20.07
3	0.34	0.24	1.01	0.99	2.50	2.51	5.06	5.01	10.12	10.00	20.03	20.05
4	0.29	0.19	1.05	1.00	2.46	2.50	5.02	4.99	9.99	9.99	19.97	20.12
5	0.31	0.23	0.98	1.05	2.49	2.50	5.01	4.98	9.98	9.99	20.03	20.11
6	0.28	0.24	1.01	0.98	2.49	2.50	5.04	5.01	9.99	10.01	20.07	20.08
7	0.32	0.24	1.01	1.00	2.50	2.49	5.02	4.99	9.94	10.00	20.04	20.11
8	0.27	0.24	0.98	0.98	2.51	2.50	5.02	4.99	10.00	10.00	20.13	20.07
9	0.34	0.24	1.00	0.99	2.46	2.51	5.01	4.99	9.98	9.99	20.20	20.07
10	0.30	0.22	1.01	0.99	2.49	2.50	5.02	4.99	9.94	10.00	20.07	20.07
Average	0.30	0.23	1.01	1.00	2.49	2.50	5.04	4.99	10.00	10.00	20.07	20.08
Standard deviation (±)	0.02	0.02	0.02	0.02	0.02	0.0	0.03	0.01	0.05	0.01	0.07	0.03
Coefficient of variation—%	8.19	6.68	2.42	1.91	0.67	0.0	0.60	0.22	0.49	0.07	0.34	0.13

* Mohr method.
† Mercurimetric method.

is greater than 7.9; in the pH range 7.9–3.6, the color will be blue to blue-green; below a pH of 3.6, the solution will be yellow. Adjust the pH to slightly less than 3.6 with 0.2*N* nitric acid, adding five drops in excess of the amount needed to develop the initial definite yellow color of the solution. To the acidified yellow solution add, by means of a buret, standardized mercuric nitrate reagent until a violet color persists throughout the solution. A few drops before this violet endpoint is reached, an orange color will appear, which serves as a warning that the titration should proceed slowly and with vigorous swirling. The color changes associated with the endpoint are best seen against a white background.

Evaluation

In order to evaluate the method, standard sodium chloride solutions in 2-liter quantities were prepared in volumetric flasks by accurate dilution of the stock sodium chloride solution with distilled water. The chloride ion concentrations were 2.5, 10, 25, 50, 100, and 200 ppm. The contents of each flask were divided into two equal portions. One portion was analyzed in replicate (ten times) by the Mohr method, and the second was analyzed, also in replicate, by the mercurimetric method. A comparison of the results of the two methods, combined with a statistical analysis, is shown in Table 1.

TABLE 2

Chloride in Field Samples

Sample No.	Trickling Filter Effluent		Activated Sludge Effluent		Algae Pond Effluent		Primary-Treatment Effluent		Tap Water		Well Water	
	Chloride Found—*mg/100 ml*											
	*A**	*B*†	*A**	*B*†	*A**	*B*†	*A**	*B*†	*A**	*B*†	*A**	*B*†
1	2.26	2.16	1.37	1.29	3.53	3.48	2.49	2.49	0.64	0.60	6.81	6.76
2	2.13	2.11	1.30	1.29	3.52	3.46	2.52	2.47	0.66	0.61	6.79	6.82
3	2.13	2.09	1.28	1.29	3.47	3.47	2.50	2.49	0.65	0.62	6.78	6.77
4	2.12	2.09	1.29	1.29	3.48	3.49	2.54	2.49	0.66	0.60	6.79	6.76
5	2.09	2.09	1.34	1.29	3.47	3.52	2.52	2.49	0.64	0.60	6.79	6.77
6	2.14	2.15	1.28	1.31	3.50	3.47	2.55	2.48	0.67	0.60	6.78	6.76
7	2.09	2.12	1.30	1.28	3.45	3.47	2.50	2.49	0.65	0.61	6.73	6.77
8	2.13	2.12	1.33	1.30	3.52	3.53	2.50	2.49	0.65	0.61	6.78	6.77
9	2.14	2.12	1.32	1.33	3.47	3.48	2.51	2.47	0.66	0.62	6.73	6.77
10	2.14	2.12	1.28	1.30	3.47	3.47	2.49	2.49	0.64	0.60	6.73	6.77
Average	2.14	2.12	1.31	1.30	3.49	3.48	2.51	2.49	0.65	0.61	6.77	6.77
Standard deviation (±)	0.04	0.02	0.03	0.01	0.03	0.02	0.02	0.01	0.01	0.01	0.03	0.02
Coefficient of variation—%	2.09	1.08	2.20	1.03	0.75	0.64	0.78	0.31	1.53	1.29	0.42	0.25

* Mohr method.
† Mercurimetric method.

Six typical samples encountered in the field of sanitary engineering—tap water, well water, trickling filter effluent, activated sludge effluent, primary-treatment sewage effluent, and algae oxidation pond effluent—were apportioned and analyzed in a similar fashion. In each instance, a 2-liter sample was divided into equal portions, each of which was further subdivided into 100-ml aliquots. The tap and well water samples required no clarification; the 100-ml aliquots of all other samples

were treated with aluminum hydroxide prior to analysis. A comparison of the results is shown in Table 2.

Replicate samples containing 10 mg of chloride ion were adjusted with very dilute nitric acid to cover a pH range from 4.1 to 2.5. The samples were titrated with mercuric nitrate standardized by the normal procedure. Figure 1 shows the relationship between the volume of mercuric nitrate required in a titration and the pH of a sample prior to the titration.

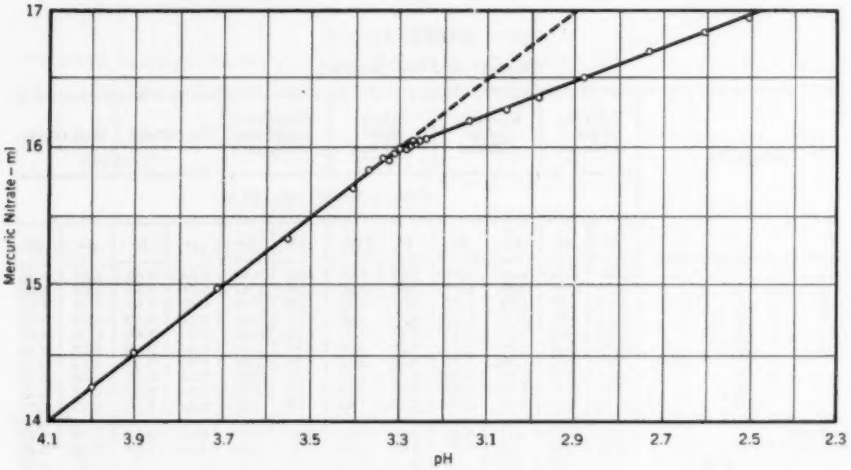

Fig. 1. Effect of pH on Volume of Titrant

It is apparent that pH 3.3 is the critical point.

Previous investigators of the mercurimetric method have shown that the hydrogen ion concentration is a critical variable. In Clarke's modification (*4*), all samples are adjusted as close as possible to an optimum pH of 3.3. Figure 1 shows graphically that, at a pH of approximately 3.3 or less, the volume of titrant is much less critical than at higher pH values. Rather than select 3.3 as the optimum pH, it seems desirable to set it as the maximum allowable pH, thus insuring that the titration will proceed on the portion of the curve that minimizes errors due to pH variations. The actual error, however, is negligible when the analysis is run at the same pH at which the mercuric nitrate was standardized.

The pH of a sample to be analyzed is adjusted by the addition of dilute nitric acid ($0.2N$) to a value of 3.6, as indicated by the formation of the yellow color owing to bromphenol blue. Five additional drops of the dilute nitric acid shift the pH downward, without further color change, to an approximate value of 3.1, which is definitely on the minimal-error portion of the curve (Fig. 1).

Bromphenol blue in the mixed indicator serves primarily as the pH indicator; in addition, it improves the

sharpness of the endpoint by masking, with its yellow background color, the pale color that diphenylcarbazone develops during the course of titration with mercuric nitrate.

The untreated field samples tested were all found to be approximately neutral, the expected normal value; in addition, these samples all had some degree of natural buffering capacity which was almost completely exhausted below a pH of 3.6. As there was no buffering capacity whatsoever in the standard chloride samples prepared from the stock sodium chloride solution, it was found necessary to adjust the pH of these standard samples with a much more dilute nitric acid solution (approximately 0.02*N*). Using the more dilute acid to adjust the pH of the standard samples, but following the exact procedure outlined for the field samples, resulted in an almost complete elimination of error due to variations in pH. The acidity of the mercuric nitrate standard solution was small enough to cause only negligible errors in an average titration, an observation which is consistent with reported results (*5*).

Generally, the chloride ion concentrations of samples encountered in the water or waste treatment plant laboratory fall within the range of 2.5 to 200 mg per liter. For that reason, these values were chosen as the limits in preparing standard chloride samples. The results of replicate analysis of these samples by both the Mohr and mercurimetric methods are given in Table 1. Statistical analysis shows that there is little difference in precision between the two methods; the standard deviation is approximately ± 0.03 mg per 100-ml sample for all chloride concentrations in the range studied. In both methods, the limit of error is well within the acceptable value of 1 per cent, except for low chloride concentrations. For the minimum chloride ion concentration (0.25 mg per 100 ml), the accuracy falls off approximately 15 per cent, which is equivalent to an absolute error of less than 0.5 mg per liter. Such accuracy is generally acceptable for low concentrations. It is noteworthy that the mercurimetric method is slightly more accurate, but the difference is so small that it is negligible.

When a comparison of the results is made on field samples, the same degree of precision is observed for both methods (see Table 2), and it is of the same order of magnitude as found in the standard samples. In slightly colored samples, the addition of more indicator than is normally used in the mercurimetric method was found to sharpen the endpoint, and there was no appreciable effect on the apparent accuracy of the method. In one instance, it was possible to check the absolute accuracy using a field sample: Activated sludge effluent from a pilot scale plant using a synthetic sewage of known chloride concentration was tested. The results for both methods checked within 0.2 per cent of the known chloride ion concentration.

The mercurimetric endpoint is much easier to see, regardless of the chloride concentration, because there is no masking or shading by turbidity. Overshooting the endpoint in the mercurimetric method results in the immediate development of a very intense purple color, whereas, in the Mohr method, a much more subtle and gradual change occurs when the endpoint is passed. Another advantage of the mercurimetric method is that the endpoint corresponds to the stoichiometric

point, while a blank correction of approximately 0.2 ml is required by the Mohr method, using the standard method of analysis (*1*).

The anions and cations generally found in water and sewage plant laboratory samples offer no interference in the mercurimetric method even when present in relatively gross amounts. Sulfite ion interferes when its concentration exceeds 10 mg per liter. Pretreatment of the sample with a few drops of 30 per cent hydrogen peroxide eliminates this interference. Chromate and ferric ions interfere when their concentrations exceed 10 mg per liter and must be removed before determining chloride mercurimetrically. They are, however, generally present only in trace quantities.

Conclusion

The analytical method described in this paper is applicable to the determination of chloride ion in most samples encountered in the water or sewage plant laboratory. The precision, accuracy, and simplicity of the method compare favorably with the Mohr method and have the advantage of a sharp endpoint.

Acknowledgment

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Assembly, Operation, and Maintenance of Fire Hydrants

This material is reprinted from Loss Prevention Data Sheet 3–20 (Water Supplies), published in December 1951 by the Eng. Div., Factory Mutual Fire Insurance Cos., Boston, Mass.

THIS paper describes the assembly, operation, and maintenance of those hydrants most likely to be found in fire protection systems. In general, the bonnet, barrel, and foot piece of hydrants are of cast iron. Important working parts are usually of bronze. Valve facings may be of rubber, leather, or composition material.

Dry-Barrel Hydrants

Dry-barrel hydrants are of the compression, gate, or knuckle-joint types, according to the valve mechanism that is located in the foot piece. To prevent freezing, any water in the hydrant drains out at the bottom through a small valve which opens as the hydrant valve approaches the closed position.

When hydrants do not drain properly, attempt to clear the drain hole by opening the hydrant one or two turns with the hose outlets closed. If this is not successful, all compression type hydrants except two and some of the gate and knuckle-joint hydrants must be dug up sufficiently to expose the drain hole, and the drain hole must be cleared using a rod of suitable diameter and length. With other gate and knuckle-joint types, the hydrant can be disassembled, and then a rod may be driven through the drain hole. See Assembly 10 and Assembly 15 for details of freeing drains of the two compression hydrants noted above without digging up the hydrant.

Where ground water backs up into the barrel through the drain hole, the drain hole may be plugged and the barrel kept pumped out.

When hydrants leak at the valve, the cause may be an obstruction or a defective valve facing or seat ring. Attempt to remove any obstruction by opening the valve wide and flowing water from the hydrant outlet. If this is not successful, then disassemble the hydrant and remove the obstruction. To install a new valve facing, disassemble the hydrant. To replace a damaged seat ring, the hydrant must be disassembled and, in a few compression, and all gate and knuckle-joint, types, the hydrant must be dug up also.

In certain compression type hydrants, a special socket-key wrench supplied by the manufacturer is required to remove a retainer ring or the seat ring before the hydrant valve mechanism can be removed. When such a wrench is not available at the plant or local public water department, one can be fabricated using a suitable length of wrought-iron or steel pipe of the same diameter as the lug circle on the retainer or seat ring. The bottom of this pipe should be slotted to engage the lugs, which are usually 90 deg apart. When the diameter of the lug

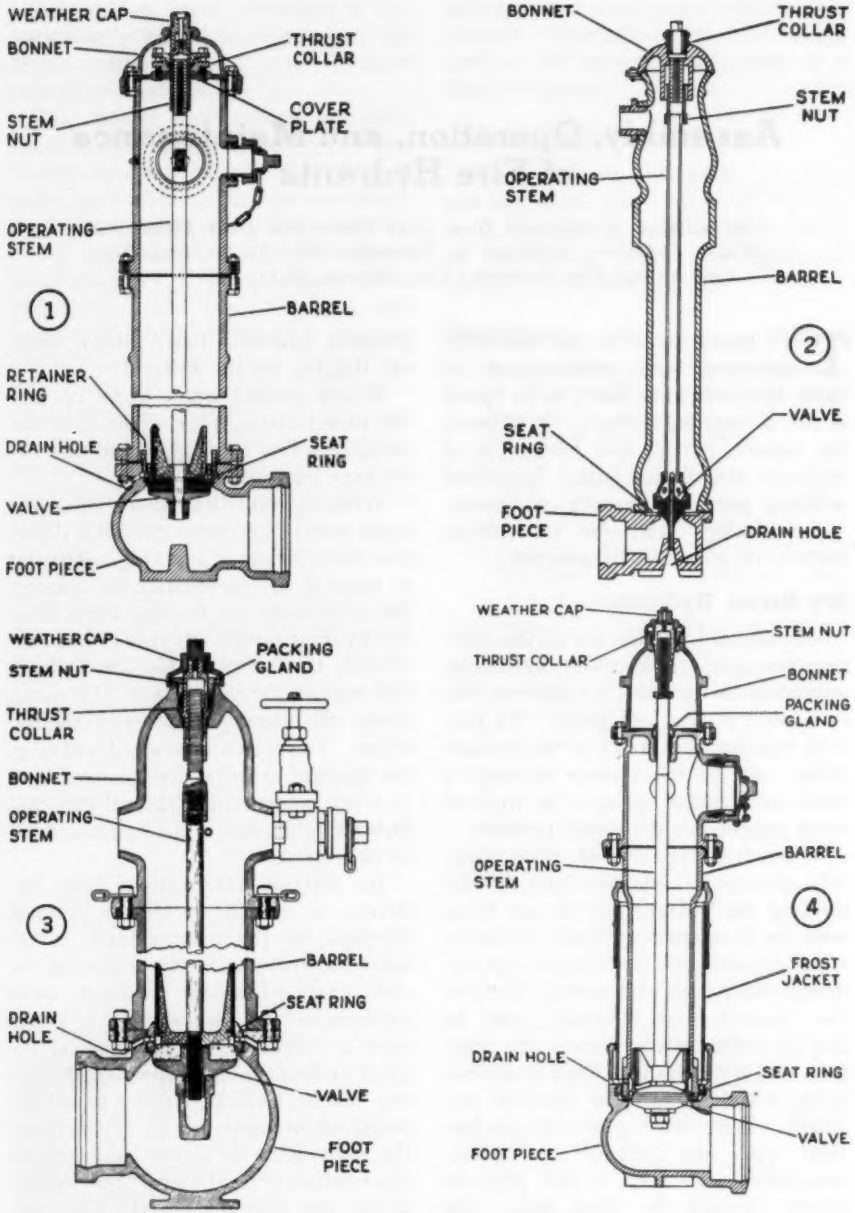


Fig. 1–4. Compression Type Hydrants

circle is not a standard size of wrought-iron or steel pipe, a smaller-diameter pipe may be used and bosses of sufficient length to engage the lugs welded to the outside of the pipe. When such a wrench is fabricated, a piece of flat steel, of the same diameter as the pipe, with a hole that would fit over and center the operating stem in the pipe, should be welded to the top of the pipe. The stem nut should be screwed down against this piece of steel so that there will be no tendency for the pipe to slip and burr the lugs. This pipe may be turned by a chain type wrench. Turning by using a wrench on the stem nut is not recommended.

Lubrication of the threads of the stem nut is accomplished by removing the bolt in the top of the weather cap or stem nut and pouring oil in the bolt hole. Some hydrants have grease fittings in place of these bolts.

When hydrants leak at the packing, tighten the packing gland or replace the packing.

Wet-Barrel Hydrants

The wet-barrel ("California type") of hydrant (Fig. 16) is for use in climates where there is no possibility of freezing. It usually has a valve of the compression type at each outlet but may have one such valve located in the bonnet that controls the flow of water to all outlets.

When such hydrants leak at the valve, the cause may be an obstruction or a defective valve facing. Attempt to remove an obstruction by opening the valve and flowing water from the outlet. If this is not successful, then disassemble the hydrant and remove the obstruction. It is necessary to disassemble the hydrant to install a new valve facing.

When hydrants leak at the packing, tighten the packing gland or replace the packing.

Operating Details

Table 1 (pages 274–76) and Fig. 1–16 give the pertinent data for various makes of hydrants. Similar types of hydrants of one or more manufacturers are illustrated by one drawing.

Method of Assembly

Assembly 1 (*Fig. 1*). Shut off the water. Unbolt and lift off the weather cap. Unbolt and lift off the bonnet. Turn the stem nut in the "open" direction until it disengages the operating stem. Lift off the stem nut, thrust collar, and cover plate as a unit. Insert a special socket-key wrench into the barrel over the operating stem until the slots in the bottom of the wrench engage the lugs on the retainer ring. Turn the wrench counterclockwise and unscrew the retainer ring. Lift out the wrench and hydrant mechanism. Reassemble in reverse order.

Assembly 2 (*Fig. 2, 5, and 9*). Shut off the water. Unbolt the bonnet. Remove the bonnet and operating mechanism as a unit. Reassemble in reverse order.

Assembly 3 (*Fig. 3 and 13*). Shut off the water. Open the hydrant wide. Unbolt the bonnet. Turn the stem nut in the "open" direction until it disengages the operating stem. Lift off the stem nut and bonnet as a unit. Insert a special socket-key wrench into the barrel over the operating stem until the slots in the bottom of the wrench engage the lugs on the seat ring. Turn the wrench counterclockwise and unscrew the seat ring. Lift out the wrench and hydrant mechanism. Reassemble in reverse order.

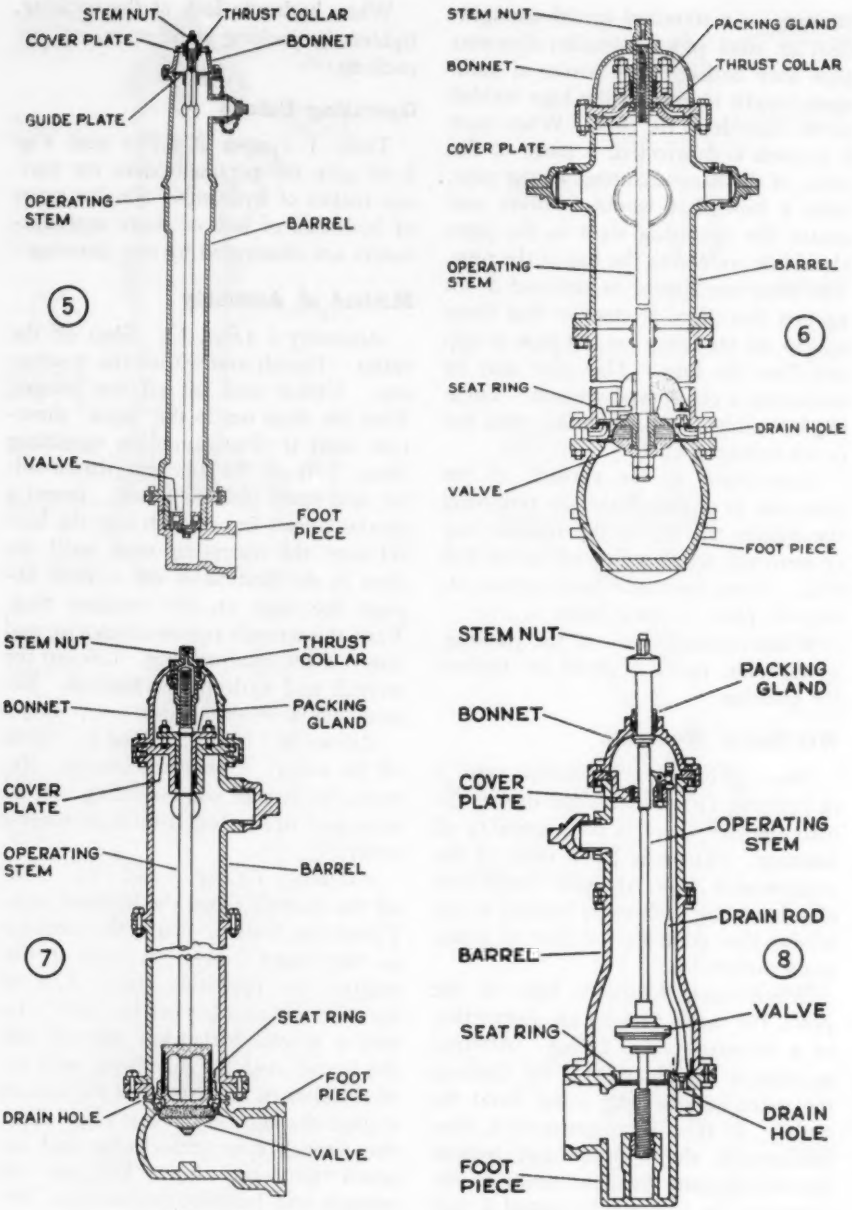


Fig. 5–8. Compression Type Hydrants

Assembly 4 (*Fig. 4*). Shut off the water. Open the valve a few turns. Unscrew the barrel from the foot piece by means of a chain type pipe wrench and lift the barrel and entire assembly out of the frost jacket. Then turn the stem nut in the "open" direction to open the valve, so that the valve, seat ring, and drain mechanism can be removed. Reassemble in reverse order.

Assembly 5 (*Fig. 6*). Shut off the water. Open the hydrant wide. Unbolt the bonnet. Turn the stem nut in the "open" direction until it disengages the operating stem. Lift off the stem nut and bonnet as a unit. Lift off the cover plate. Pull up on the operating stem until an ordinary wrench can be attached to the square, unthreaded portion. Then, while the valve is in tight contact with the seat ring, turn the stem counterclockwise to unscrew the seat ring. A short tee wrench may have been supplied to fit over the operating stem, although any wrench large enough to fit the operating stem may be used. Lift out the seat ring and operating mechanism. Assemble in reverse order.

Assembly 6 (*Fig. 4*). Shut off the water. Open the valve a few turns. Lift the sliding top of the frost jacket to expose a flange and bolts near ground level. In this hydrant, these bolts extend down and fit into slots in the foot piece. Remove the nuts from the bolts and lift out the barrel and entire assembly. The barrel rests on a rubber gasket in the foot piece to make a tight joint when the nuts are tightened above the flange. Turn the stem nut in the "open" direction to open the valve, so that the valve, seat ring, and drain mechanism can be removed. Reassemble in reverse order.

Assembly 7 (*Fig. 3*). Remove the weather cap. Unscrew and remove the packing gland (which also acts as the thrust collar). Unbolt and remove the bonnet. Insert a special socket-key wrench into the barrel over the operating stem until the slots engage the lugs of the valve seat ring. Fasten the wrench by screwing the stem nut down over the threaded portion of the operating stem that extends above the top of the wrench. *Shut off the water.* Break the bond existing between the seat ring and the foot piece by placing a piece of metal on top of the stem nut and striking this two or three solid blows. Turn the wrench counterclockwise to unscrew the seat ring. Lift out the wrench and hydrant mechanism. Reassemble in reverse order.

Assembly 8 (*Fig. 4*). Shut off the water. Unscrew and remove the nuts from the bolts in the flange just above the frost jacket. These bolts secure the hydrant to the frost jacket, which, in turn, is bolted to the foot piece. Lift out the barrel and entire assembly, being careful that the bolts do not fall inside. Turn the stem nut in the "open" direction to open the valve, so that the valve, seat ring, and drain mechanism can be removed. Reassemble in reverse order.

Assembly 9 (*Fig. 7*). Shut off the water. Open the hydrant wide. Unbolt the bonnet. Turn the stem nut in the "open" direction until it disengages the operating stem. Remove the bonnet and stem nut as a unit. Unbolt and remove the packing gland and cover plate. Insert a special socket-key wrench into the barrel over the operating stem and turn counterclockwise to unscrew the seat ring. Lift out the wrench and valve mechanism. Reassemble in reverse order.

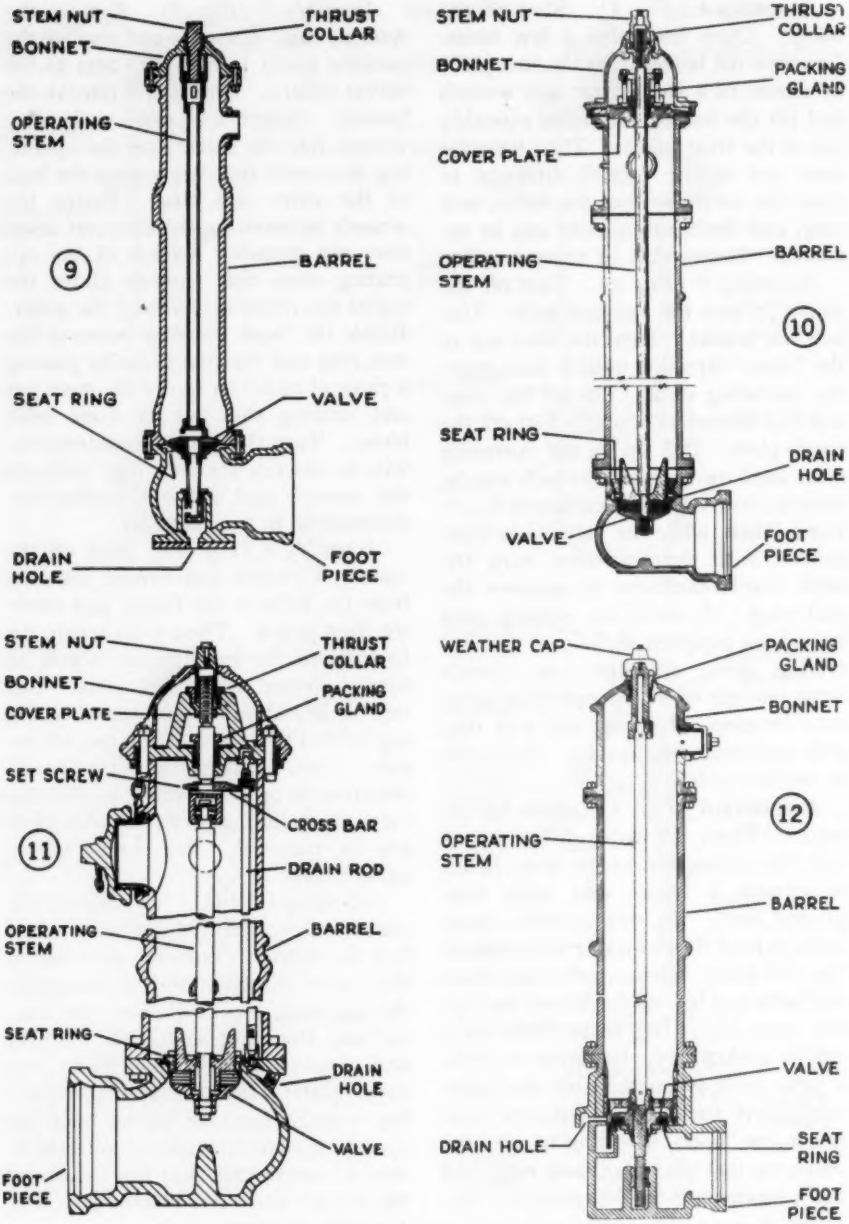


Fig. 9–12. Compression Type Hydrants

Assembly 10 (*Fig. 8*). Shut off the water. Open the valve a few turns. Unbolt and remove the weather cap. Unbolt and remove the bonnet. Lift out the cover plate and drain rod. Turn the operating stem in the "open" direction until it is disengaged from the foot piece. Lift out the operating stem and valve. Reassemble in reverse order.

To clear the drain without digging up the hydrant, close the hydrant valve. Unbolt and remove the weather cap. Unbolt and remove the bonnet. Lift out the cover plate and drain rod. Remove the drain valve from the drain rod. Force the end of the drain rod through the drain hole to remove the obstruction. Reassemble in reverse order. Open the hydrant valve with the hose outlets closed to flush out the drain hole.

Assembly 11 (*Fig. 7*). Shut off the water. Open the hydrant wide. Unbolt and lift off the bonnet. Unbolt the cover plate. Turn the stem nut in the "open" direction until it disengages the operating stem. Lift off the cover plate and stem nut as a unit. Insert a special socket-key wrench into the barrel over the operating stem until the slots engage the lugs on the seat ring. Screw the wing nut supplied with the wrench on the stem to bind the wrench to the seat ring. Turn the wrench counterclockwise to unscrew the seat ring. If the seat ring tends to stick, tap the top of the barrel and the top of the wrench head lightly with a hammer while turning the wrench. Lift out the wrench and valve mechanism. Reassemble in reverse order.

Assembly 12 (*Fig. 10*). Unscrew and remove the thrust collar. Turn the stem nut in the "open" direction until it disengages the operating stem. Unbolt and lift off the bonnet. Unbolt and remove the cover plate. Insert a special socket-key wrench into the barrel over the operating stem until the slots engage the lugs of the seat ring. Replace the stem nut on the operating stem and screw it down tight against the top of the wrench. *Shut off the water.* Turn the wrench counterclockwise to unscrew the seat ring. Lift out the wrench and valve mechanism. Reassemble in reverse order.

Assembly 13 (*Fig. 3*). Shut off the water. Open the hydrant wide. Unbolt the bonnet. Turn the stem nut or weather cap in the "open" direction until the stem nut disengages the operating stem. Lift off the stem nut and bonnet as a unit. Insert a special socket-key wrench into the barrel over the operating stem until the slots in the bottom of the wrench engage the lugs on the seat ring. Bolt on the guide plate (supplied with the wrench) in place of the bonnet. Pass a rod or handle through the upper end of the wrench and turn it counterclockwise to unscrew the seat ring. Unbolt and remove the guide plate. Lift out the wrench and valve mechanism. Reassemble in reverse order.

Assembly 14 (*Fig. 3*). Unscrew the packing gland. Turn the stem nut counterclockwise until it disengages the operating stem. Unbolt and remove the bonnet. Insert a special socket-key wrench into the barrel over the operating stem until the slots in the bottom of the wrench engage the lugs on the seat ring. Replace the stem nut on the operating stem and screw it down tight against the top of the wrench. *Shut off the water.* Insert a pipe or rod in the end of the wrench handle and turn it counterclockwise to unscrew the seat ring. Lift out the wrench and

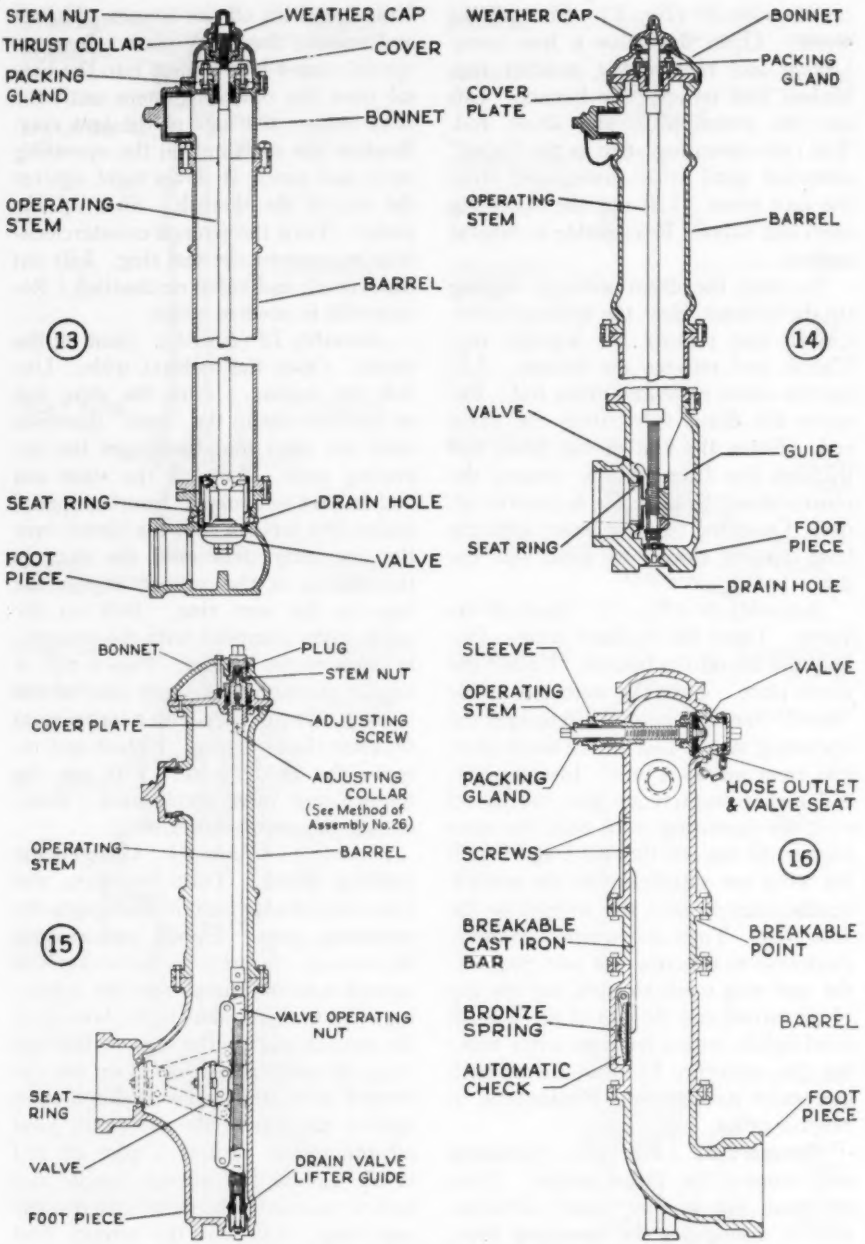


Fig. 13–16. Compression, Gate, Knuckle-Joint, and Wet-Barrel Types

valve mechanism. Reassemble in reverse order.

Assembly 15 (*Fig. 11*). Shut off the water. Open the hydrant wide. Unbolt and lift off the bonnet. Unbolt the cover plate. Turn the stem nut in the "open" direction until it disengages the operating stem, while holding the cover plate from turning. Lift off the cover plate, thrust collar, and stem nut as a unit. Unscrew the thrust collar and remove the stem nut from the cover plate. Lift out the drain rod. Loosen the set screw and remove the cross bar. Insert a special socket-key wrench into the barrel over the operating stem until the slots in the bottom of the wrench engage the lugs in the seat ring. Replace the stem nut on the operating stem and screw it down tight against the top of the wrench. Turn the wrench counterclockwise to unscrew the seat ring. Lift out the wrench and valve mechanism. Reassemble in reverse order.

To clear the drain without digging up the hydrant, shut off the water. Unbolt and lift off the bonnet. Unbolt the cover plate. Turn the stem nut in the "open" direction until it disengages the operating stem, while holding the cover plate and stem nut as a unit. Lift out the drain rod. Force the end of a rod or wire of suitable diameter through drain hole to remove the obstruction. Reassemble in reverse order. Turn on the water. Open the hydrant valve with hose outlets closed to flush out the drain hole.

Assembly 16 (*Fig. 1*). Shut off the water. Open the hydrant wide. Unbolt and remove the bonnet. Unbolt and remove the cover plate. Turn the stem nut in the "open" direction until it disengages the operating stem. Insert a special socket-key wrench into the barrel over the operating stem until the slots engage the lugs on the retainer ring. Turn the wrench counterclockwise and unscrew the retainer ring. Lift out the wrench and hydrant mechanism. Reassemble in reverse order.

Assembly 17 (*Fig. 12*). Shut off the water. Unbolt and lift off the weather cap. Unbolt the bonnet and remove the bonnet and packing gland as a unit. Turn the operating stem in the "open" direction until it disengages the foot piece. Lift out the operating stem and valve mechanism. Reassemble in reverse order.

Assembly 18 (*Fig. 14*). Shut off the water. Open the hydrant a few turns. Unbolt and remove the weather cap. Unbolt and lift off the bonnet. Unbolt the cover plate and lift off the cover plate and packing gland as a unit. Lift out the valve mechanism and operating stem as a unit. Reassemble in reverse order.

Assembly 19. The operating mechanism of the "Walker" hydrant is such that the valve moves downward from the seat into the foot piece as it is opened. Shut off the water. Open the hydrant a few turns. Unbolt and lift off the bonnet. Unbolt and lift off the cover plate. Lift out the valve mechanism and operating stem as a unit. Reassemble in reverse order, making sure that the wings on the back of the valve mechanism are slipped inside of the guide slot in the foot piece.

Assembly 20. The operating mechanism of the "Improved" hydrant is such that the valve moves downward from the seat into the foot piece as it is opened. The guide in the foot piece is removable and is not cast as part of the foot piece. Shut off the water. Open the hydrant a few turns. Unbolt and remove the bolts in the flange at

the base of the bonnet. Turn the stem nut in the "open" direction until it disengages the operating stem. Lift off the bonnet and stem nut as a unit. Lift the guide out of the foot piece. Lift out the operating stem and valve mechanism as a unit. Reassemble in reverse order.

Assembly 21 (*Fig. 14*). Shut off the water. Dig up the hydrant to expose the bolts in the flange at the foot piece. Unbolt and remove these bolts. Lift off the entire hydrant. Reassemble in reverse order.

Assembly 22 (*Fig. 14*). Shut off the water. Open the hydrant a few turns. Unbolt and lift off the bonnet. Unbolt the cover plate and lift off the cover plate and packing gland as a unit. Lift out the valve mechanism and operating stem as a unit. Reassemble in reverse order.

Assembly 23. Shut off the water. Open the hydrant wide. Unbolt and lift off the bonnet. Unbolt the cover plate. Turn the stem nut in the "open" direction until it disengages the operating stem. Lift off the stem nut and cover plate. Lift out the valve mechanism and operating stem as a unit. Reassemble in reverse order.

Assembly 24 (*Fig. 14*). Shut off the water. Open the hydrant two or three turns. Unbolt and remove the weather cap. Unbolt and lift off the bonnet. Unbolt the cover plate and remove the cover plate and packing gland as a unit. Lift out the valve mechanism and operating stem as a unit. When the valve reaches the top of the hydrant, turn it to bring it out through the widest diameter. In reassembling, have the valve two turns from the bottom of the thread of the operating stem. Insert the valve through the widest diameter of the top; then turn it so that the face of the valve is toward the inlet of the hydrant. Lower it carefully by the operating stem until the valve reaches its proper seating position against the face of the seat ring. Screw the stem five or six turns in the "open" direction to center the drain mechanism in the proper location and to relieve the gate from the seat. Replace and bolt the cover plate, bonnet, and weather cap.

Assembly 25. The operating mechanism of the "Holyoke" hydrant is such that the valve moves downward from the seat into the foot piece as it is opened. The guide in the foot piece is removable and is not cast as part of the foot piece. Shut off the water. Open the hydrant wide. Excavate around the entire hydrant to uncover the back of the foot piece. Unbolt and remove the bolts in the flange on top of the foot piece. Lift the hydrant barrel and bonnet over the operating stem. Remove both bolts from the back of the foot piece. Lift out the guide. Lift out the valve mechanism and operating stem. Reassemble in reverse order.

Assembly 26 (*Fig. 15*). Shut off the water. Open the hydrant wide. Unbolt and lift off the bonnet. Unbolt the cover plate and remove the cover plate and stem nut assembly as a unit. Lift out the valve mechanism and operating stem as a unit. If the valve mechanism tends to stick, wrap a piece of chain around the operating stem and pry it loose with a wrench handle or bar, and then lift out the valve mechanism.

Reassembly 26 (*"New Style" hydrant*). Screw the drain valve lifter guide out as far as it will go; then turn it back one full turn. See that the wings on the drain valve lifter guide are parallel to the face of the valve.

Insert the valve assembly in the groove in the foot piece, taking care to hold the drain valve snugly against the back of the barrel while lowering it. Replace the cover plate and stem nut assembly and bolt down the cover plate. Remove the plug from the stem nut and insert a screwdriver through the hole. Screw the adjusting screw down against the top of the operating stem and back out one-half turn. Replace and bolt down the bonnet.

Reassembly 26 ("Old Style" hydrant). Screw the drain valve lifter guide in as far as it will go and then back out either one-half or one full turn. See that the wings on the drain valve lifter guide are parallel to the face of the valve. Insert the valve assembly in the groove in the foot piece, taking care to hold the drain valve snugly against the back of the barrel while lowering it. See that the adjusting collar at the top of the operating stem is in its original position, to allow the stem nut to engage the operating stem fully, yet prevent end play of the operating stem. Replace the cover plate and stem nut assembly and bolt down the cover plate. Replace and bolt down the bonnet.

Assembly 27 (Fig. 15). Shut off the water. Open the hydrant wide. Unbolt the lift off the bonnet. Unbolt the cover plate and remove the cover plate and stem nut assembly as a unit. Lift out the valve mechanism and operating stem as a unit. Reassemble in reverse order, taking care to hold the drain valve snugly against the back of the barrel while lowering it, so that it fits into the opening in the base of the foot piece.

Assembly 28 (Fig. 15). Shut off the water. Open the hydrant wide. Unbolt and lift off the bonnet. Unbolt the cover plate. Lift out the cover plate, operating stem, and valve mechanism as a unit. Reassemble in reverse order, taking care to see that the drain valve fits into the opening in the base of the foot piece and the wings on the valve operating nut fit into the groove in the back of the foot piece.

Assembly 29 (Fig. 16). Shut off the water. Open the hose outlet valve a few turns. Unscrew and remove the hose outlet and valve seat. Unscrew and remove the packing gland. Turn the operating stem in the "close" direction until the valve protrudes from the barrel. Grasp the valve and turn in the "close" direction until the threads of the operating stem are beyond the sleeve. Then remove the valve and operating stem. Reassemble in reverse order.

Assembly 30 (Fig. 16). These wet-barrel hydrants differ from the sketch only in that the sleeve through which the operating stem passes is cast as part of a flange that is bolted over an opening in the barrel larger than the valve diameter. Shut off the water. Open the hose outlet valve a few turns Unbolt the flange containing the sleeve and operating stem. Remove the flange and valve mechanism as a unit. Reassemble in reverse order.

TABLE 1

Hydrant Data

Manufacturer and Location	Model No. or Name	Parts Available	Fig. No.	Assembly Method No.	No. of Turns to Open		
					4 in.	5 in.	6 in.
Compression Type							
American Foundry Co. St. Louis, Mo.	AWWA Standards	yes	1	1	11	15	24
	F.M.	yes	1	1		15	24
	Natl. Type A, No. 61–63, 66	yes	2	2	15		
Bawden Machine Co. Toronto, Ont.	Kerr, F.M.	yes	3	3		9½	12½
	Kerr, 1925	yes	4	4		?	
	Kerr, New Type	yes	3	3	11	12	15
Bourbon Copper & Brass Wks. Co. Cincinnati, Ohio	Improved Patent	yes	4	4	8	8	14
	Improved Standard	yes	5	2	8	8	14
Cambridge Machine & Valve Co.* Cambridge, Mass.	†	no	10	12		17	
Canada Foundry Co. Toronto, Ont.	Toronto†	no	4	4		?	
Chapman Valve Mfg. Co. Indian Orchard, Mass.	List 88	yes	6	5	17	18	
Coffin Valve Co. Boston, Mass.	†	no	4	6	?	12	
Columbian Iron Wks.‡ Chattanooga, Tenn.	Standard	yes	3	7	16	16	19
	Improved	yes	3	7	16	16	21
	Underwriter	yes	3	7		18	24
Cook, A. D., Inc. Lawrenceburg, Ind.	Cook†	yes	3	3		10	
Darling Valve & Mfg. Co. Williamsport, Pa.	Darling	yes	6	5	17	17	20
	Quickfix	yes	6	5	17	17	20
Drummond, M. J., & Co. New York, N.Y.	Glamorgan†	no	4	8	?	22	22
	Underwriter†	no	4	8	?	22	22
East Jordan Iron Wks.§ East Jordan, Mich.	HC	yes	7	9	10	11½	
	HD—Detroit or Michigan Patent	yes	4	4	9	8	11
	Michigan with frost jacket†	yes	4	4	9½	9½	
	Michigan without frost jacket†		7	9	?	?	?
	Underwriters'†		4	4	?	?	?
	Metropolitan†		11	15	?	?	?
	Model O†		3	3	?	?	?
	Detroit Standard†	yes	4	4			10
Eddy Valve Co. Waterford, N.Y.	Eddy	yes	8	10	13	12	16
Fales & Jenks Machine Co. Pawtucket, R.I.	†	no		?	13	12	16
Filer & Stowell Co. Milwaukee, Wis.		yes	7	9		21	
Flower-Stephens Mfg. Co.	see East Jordan Iron Wks.						
Flower Valve Mfg. Co.	see East Jordan Iron Wks.						
General Fire Extinguisher Co. Providence, R.I.	G. F. E.†	no	3	7		22	22
Glamorgan Pipe & Foundry Co.	see Drummond, M. J., & Co.						

* Formerly Cambridge Machine & Tool Co.
† No longer manufactured.
‡ Division of Mueller Co.
§ Successors to Michigan Brass & Iron Wks., Roe Stephens Mfg. Co., Flower Valve Mfg. Co., Flower-Stephens Mfg. Co., and Michigan Valve & Foundry Co.

TABLE 1—*Hydrant Data (contd.)*

Manufacturer and Location	Model No. or Name	Parts Available	Fig. No.	Assembly Method No.	No. of Turns to Open		
					4 in.	5 in.	6 in.
Compression Type (*contd.*)							
Greenberg's, M., Sons San Francisco, Calif.	K-65†	yes	3	3	3¼		
	K-70†	yes	3	3	3¼		
	K-75†	yes	3	3		6	
	K-100†	yes	3	3		6	
	K-125†	yes	3	3			6
Jenkins Bros. Montreal, Que.	Lofton Patent†	no		?	17	24	?
Johnson City Foundry & Machine Wks. Johnson City, Tenn.		yes	7	9	11½	11½	
Kennedy Valve Mfg. Co. Elmira, N.Y.	Safetop	yes	7	11	11½	13½	17
	Standard	yes	7	11	11½	13½	17
	New Type	yes	7	11	11	12	15
Kerr Engine Co.	see Bawden Machine Co.						
Kupferle, J. C., Foundry Co. St. Louis, Mo.	Eclipse No. 3	yes	9	2	3¼		
	Eclipse No. 6	yes	9	2	3¼		
	Eclipse No. 10	yes	9	2		6	
	Eclipse No. 65	yes	3	3	3¼		
	Eclipse No. 70	yes	3	3	3¼		
	Eclipse No. 75	yes	3	3		6	
	Eclipse No. 100	yes	3	3		6	
	Eclipse No. 125	yes	3	3			6
M & H Valve & Fittings Co. Anniston, Ala.	Standard	yes	10	12	9¼	14¼	23¼
	Traffic	yes	10	12	9¼	14¼	23¼
Manistee Iron Wks. Co. Manistee, Mich.	Manistee	yes	10	12	8¼‖		11¼
McAvity, T. & Sons St. John, N.B.	World	yes	3	13	9	11	
	Underwriter	yes	3	13		11	
	A1	yes	3	13	11¼		
Michigan Brass & Iron Wks.	see East Jordan Iron Wks.						
Michigan Valve & Foundry Co.	see East Jordan Iron Wks.						
Mueller Co.	see Columbian Iron Wks.						
Multiplex Mfg. Co. Berwick, Pa.	Crispin†	yes	3	14	?	?	?
Nelson, N. O., Co. St. Louis, Mo.	Nonco†	yes	9	2	?	?	?
Reading-Pratt & Cady Div.‡ Bridgeport, Conn.	Old Style†	no	1	16	14	20	
	New Style†	no	1	16		21	21
Roe Stephens Mfg. Co.	see East Jordan Iron Wks.						
Smith, A. P., Mfg. Co. East Orange, N.J.	O'Brien Standard	yes	11	15	10¼¶	17	17
	O'Brien Hi Pressure	yes	11	15	10¼¶	17	17
	Smith Protectop	yes	11	15	10¼¶	17	17
	O'Brien Class C	yes	11	15	10		
Traverse City Iron Wks. Traverse City, Mich.	TCIW	yes	12	17		7	8
Waterous Co.** St. Paul, Minn.	Old Style & Improved Frost Jacket	yes	4	4	14	18	15
	Nonjacket	yes	13	3	14	18	15
Wood, R. D. & Co. Philadelphia, Pa.	Mathews 1898	yes	4	4	15	18	21
	Improved Mathews	yes	4	4	16	20	23

‖ For 4½-in. size.
‡ Division of American Chain & Cable Co.; formerly Pratt & Cady Co.
¶ Also made in 4½-in. size, 13 turns to open.
** Formerly Waterous Fire Engine Co.

TABLE 1—*Hydrant Data (contd.)*

Manufacturer and Location	Model No. or Name	Parts Available	Fig. No.	Assembly Method No.	No. of Turns to Open		
					4 in.	5 in.	6 in.
Gate Type							
Bawden Machine Co. Toronto, Ont.	Ludlow Pattern††	no	14	18	25		
Canadian Ludlow Valve	see Ludlow Valve Mfg. Co.						
Coffin Valve Co. Boston, Mass.	Walker†† Improved††	no no		19 20	20 19	23 ?	26 ?
Chapman Valve Mfg. Co. Indian Orchard, Mass.	List 80†† List 81†† List 82††	yes no yes	14 14 14	21 21 22	14 20	 18 20	 20 25
East Jordan Iron Wks.‡‡ East Jordan, Mich.	Michigan—Galvin††	?		23	11	13	15
Flower-Stephens Mfg. Co.	see East Jordan Iron Wks.						
Flower Valve Mfg. Co.	see East Jordan Iron Wks.						
Glamorgan Pipe & Foundry Co. Lynchburg, Va.	††	no		18		22	22
Kerr Engine Co.	see Bawden Machine Co.						
Ludlow Valve Mfg. Co. Troy, N.Y.	List 75 List 85 List 90	yes yes yes	14 14 14	18 18 18	24 	 35 	 40
McAvity, T. & Sons St. John, N.B.	Round Solid Body Octagonal Flanged Body	yes yes	14 14	24 24	25½ 25½		
Michigan Brass & Iron Wks.	see East Jordan Iron Wks.					•	
Michigan Valve & Foundry Co.	see East Jordan Iron Wks.						
Norwood Engineering Co. Florence, Mass.	Holyoke†† Walker††	no no		25 19	14 20	17 23	19 26
Roe Stephens Mfg. Co.	see East Jordan Iron Wks.						
Knuckle-Joint Type							
Clow, James B., & Sons	see Iowa Valve Co.						
Greenberg's, M., Sons San Francisco, Calif.	No. 21–24 No. 25, 26 No. 27–29	yes yes yes	15 15 15	27 27 27	13 	 13 13	
Iowa Valve Co.§§ Chicago, Ill.	Old Style (prior to 1929)†† New Style	yes yes	15 15	26 26	13 13	13 13	13 13
Pacific States Cast Iron Pipe Co. Provo, Utah	Pacific	yes	15	27	13	13	
Reading-Pratt & Cady Div.‖‖ Bridgeport, Conn.	††	no	15	28	16	18	
Rensselaer Valve Co. Troy, N.Y.	Corey List 90A	yes yes	15 15	27 27	12 12	12 12	12
Wet-Barrel (California) Type							
Greenberg's, M., Sons San Francisco, Calif.	No. 71–77 No. 40LA, 45LA, 50LA, 51LA, 52GR, 53GR, 54, 56GR, 57GR	yes yes	16 16	29 30	##		

†† No longer manufactured.
‡‡ Successors to Michigan Brass & Iron Wks., Roe Stephens Mfg. Co., Flower Valve Mfg. Co., Flower-Stephens Mfg. Co., and Michigan Valve & Foundry Co.
§§ Subsidiary of James B. Clow & Sons.
‖‖ Division of American Chain & Cable Co.; formerly Pratt & Cady Co.
For 2½-in. connection, 13 turns; for pumper connection, 15 turns.

Hydrant Installation and Maintenance in Wisconsin

By William Hammann Jr.

A paper presented on Sep. 23, 1953, at the Wisconsin Section Meeting, Milwaukee, Wis., by William Hammann Jr., Engr., Water Dept., Milwaukee, Wis.

THE primary function of a hydrant is to furnish a convenient water supply outlet for use by the fire department in fighting fires. Secondary users include public utilities, other municipal departments, and contractors. As a source of supply for fire fighting, a hydrant must have ample capacity; it must be trouble free, conveniently located, rugged and durable, and easy to operate; and maintenance and repairs must be capable of being quickly, easily, and economically made.

To meet these qualifications, the Milwaukee, Wis., Water Dept. developed a hydrant of its own design in 1927–28. The hydrant, known as the "Milwaukee Standard," has a single barrel, thereby eliminating the frost case; a removable drain and main valve assembly, which obviates digging up the hydrant for repairs; and a thin tubular metal drain valve and a support in the base of the shoe to prevent chattering whenever the valve is opened. Extension pieces for the barrel make it easy to raise the hydrant without digging it up. Standardization of parts simplifies repair and maintenance.

Questionnaire Returns

Much of the information in this paper is taken from a questionnaire on hydrant problems and practices sent to a number of Wisconsin cities by Milwaukee. Replies were received from 42 communities, ranging in population from 4,100 to 110,000. Table 1 gives some general data for these cities. Similar information for Milwaukee is shown separately. In addition, "national" average figures, based on a recent AWWA survey (*1*), are included for approximately 300 cities with a population of 10,000 to 100,000 each.

The average population for the Wisconsin cities is 21,700, which is fairly close to the "national" average of 31,500. The number of hydrants per 1,000 population is 22.1 for the state, compared with 17.3 for the nation. This means that Wisconsin cities have approximately 30 per cent more hydrants for a comparable population. Both the state and the nation average approximately eight hydrants per mile of main.

Among the Wisconsin cities, there is quite a variation in the number of hydrants per square mile, the range extending from 13.1 to 240.0. This variation is probably due to the fact that there are large portions of vacant land within the confines of many of the smaller cities. Cities like Wauwatosa and Whitefish Bay, which are nearly completely built up, show high values for this item, indicating that their

streets are well mained and have sufficient hydrants on them. The high Milwaukee figure of 193.0 is due to its large industrial, commercial, and business areas, which require a relatively great concentration of hydrants.

The number of hydrants per mile of street (7.0 in Wisconsin) is a better standard of comparison than the number per mile of main. Many streets have two mains, especially in large cities; moreover, feeder and supply mains included in the total mileage throw the average off slightly.

direction of traffic flow, a practice that appears desirable under present-day traffic conditions. Moving hydrants farther away from corners on heavily traveled streets should also be given consideration.

Practically all the communities queried use 6-in. hydrant branches but only two-thirds install gate valves on the branch as called for by the National Board of Fire Underwriters (NBFU) (*2*). Approximately 60 per cent space their hydrants 500 ft apart or more. All use hydrants built according to

TABLE 1

Hydrant Data

Item	42 Wisconsin Cities			300 US Cities Avg	Milwaukee
	Min.	Max.	Avg		
Population	4,100	110,000	21,700	31,500	632,600
Area served—*sq miles*	1.3	42.0	6.9		51.2
Mains—*miles*	15.8	254.0	68.2	68.0*	1,082.0
Streets—*miles*	13.5	225.0	71.5		892.0
No. of hydrants					
Total	95	2,200	479	544	9,810
Per 1,000 pop.	13.7	43.9	22.1	17.3	15.6
Per square mile	13.1	240.0	73.2		193.0
Per mile of main	4.6	12.0	7.8	8.0*	9.1
Per mile of street	4.4	12.0	7.0		11.8

* In terms of 8-in. equivalent mains.

Installation

Nearly all of the communities replying to the questionnaire install their hydrants at the corners facing the street, with most of the hydrants on the north and east sides or closest to the water main. Although there is considerable variation, the majority of the towns place their hydrants approximately 24 in. from the curb and 18 in. above it. In almost all instances, the hydrants face the street, with only one community reporting installations at a 45-deg angle. Milwaukee itself sometimes faces hydrants at 45 deg, in the AWWA specifications (*3*), and most have standardized on a particular make. Single-barrel hydrants predominate.

It is noteworthy that no city follows AWWA and NEWWA recommendations on the use of color codes to indicate rated capacity (*4*). Several use color to designate the size of main or the source of supply. Approximately 50 per cent number their hydrants.

In Milwaukee, approximately 6,000 hydrants are drained to the sewer, a common practice until a few years ago. All new hydrants, however, are drained

to a crushed-stone sump at the hydrant base or to the ditch, as is done by most of the communities surveyed. Milwaukee has adopted the use of a prebuilt cement drain block, which is placed over the drainage openings in the base of the hydrant. This precaution was taken to prevent the clogging of drain holes from the outside. Several other cities also follow this plan.

Hydrants are placed in manholes by only one of the cities responding to the questionnaire. This rather unusual practice has some very worth-while advantages over the standard method and should be given more consideration in specific installations.

In general, the installation of hydrants by Wisconsin communities follows NBFU and AWWA suggestions and recommendations. This fact reflects the results of the interchange and dissemination of ideas at meetings of water works officials and in the literature of the field.

Maintenance

To insure that hydrants will operate perfectly under all conditions requires a systematic program of maintenance aimed at eliminating or alleviating the factors contributing to faulty performance. The NBFU suggests inspections in spring and fall, after use for fire fighting or other purposes, in freezing weather, and daily in high-value districts during protracted periods of extremely cold weather. Such a program must be carried out by water department personnel trained to perform the necessary tasks.

In all the communities surveyed, water department employees do the maintenance, although the public works department sometimes aids in removing snow around hydrants. In summer quarterly inspections in both the residential and business districts predominate, while in winter weekly inspections are made by approximately 35 per cent of the cities, with the remaining 65 per cent almost equally divided in making inspections monthly, quarterly, semiannually, or annually. In winter hydrants are checked after each use in nearly every city.

The survey revealed that 7 communities take no special precautions in winter, while 35 resort to pumping out the hydrants and 9 use antifreeze in some form. Seven plug the drain, and 2 employ manure around the hydrants. Milwaukee manures 40–50 hydrants every winter because they are always partially filled with water as a result of the high surrounding water table. A small, wooden, boxlike structure is placed around each offending hydrant and then filled with manure to a point just below the nozzle. This method has proved rather effective, but, where it is undesirable to have a box of manure on the street for 5–6 months of the year, it may be advisable to remove the drain valve, plug it, and then pump out the water. Hydrants so treated should be painted a characteristic color, indicating that every use must be reported to the water department. The survey showed that approximately half of the communities would consider or recommend such a practice in troublesome areas.

Thirty-four of the communities reporting have specially assigned men to do the inspecting of hydrants. The inspection procedure consists primarily of operating, flushing, greasing, pumping out, and checking the hydrant for leaks and defects. In most cities, these inspectors also have other duties, though sometimes not during extreme cold weather. Maintenance records are kept by 67 per cent of the cities.

In general, the questionnaire results indicate that proper hydrant maintenance is practiced.

Repair

The AWWA hydrant specifications tend to induce standardization, which will eventually decrease the cost of repairs. This reduction manifests itself in two ways: in a reduction of parts costs and in a simplification of repair procedure. Consequently, water department personnel can be trained more easily and quickly to perform the simpler and more routine operations.

According to the questionnaire returns, all the water departments repair their own hydrants, both in the field and in the shop. Repair parts are also carried in stock by all of the cities, and approximately 75 per cent stock repaired hydrants. Defective parts are replaced by good used parts in an equal percentage of the cities reporting. In Milwaukee, some of the good used parts have to be scrapped periodically to eliminate overaccumulation. The drain valve and the hydrant valve require most of the repairs, with stuffing box repairs next in frequency. Twenty-three cities reported the use of some form of rubber in the valve disc, while 11 used leather. The majority employ graphited hemp as a stuffing box packing.

Milwaukee has, in the recent years, adopted O rings in place of stuffing boxes. A few leaks have been encountered, but the exact cause has as yet not been determined. The O ring arrangement has simplified construction and, up to the present, has proved very satisfactory. Time alone will tell what the long-range results will be, but it is believed that the rings will prove just as effective and durable as the stuffing boxes.

The hydrant with a breaking ring or shear point that will shatter on impact seems to be preferred by two-thirds of the cities. This arrangement eliminates the costly necessity of digging up a hydrant every time it is struck and broken. Milwaukee, in its own design, has strengthened the barrel so that it will withstand considerable force without breaking. Many of these hydrants, after being struck, have merely been straightened, without recourse to digging and with no leaks occurring in the joint at the shoe. Thus far, the need for a breaking ring at the ground line has not been felt.

TABLE 2

Hydrant Reconditioning Costs

Item	Avg Cost per Hydrant	
	"Milwaukee" Type	Other Types
Parts	$ 6.67	$10.90
Labor	39.23	43.42
Inspection	2.23	2.23
Handling	2.50	2.50
Subtotal	$50.63	$59.05
Miscellaneous overhead (10% of above)	5.06	5.90
Total	$55.69	$64.95

The question on the cost of repairs per hydrant elicited a wide range of responses. It was difficult to compare the reported charges because of the variety of ways in which they were calculated. Figures as low as $0.50 per hydrant per year and as high as $30 per hydrant were submitted.

Milwaukee analyzed the cost of reconditioning hydrants for the period July 1952–June 1953. This analysis, based on 75 "Milwaukee Standard" hydrants and 43 of other makes, was in-

tended to show whether the cost of repairing the Milwaukee type was less than that of other hydrants in the system. The results of all the analysis are given in Table 2.

The average cost of parts for the Milwaukee type was $6.67 per hydrant, compared with $10.90 for other types. The average labor costs were, respectively, $39.23 and $43.42 per hydrant. Adding 10 per cent for overhead, the saving on repair of the Milwaukee type averaged $9.26 per hydrant. All charges were included from the time that the hydrant was moved from the pipe yard until it was returned to the yard after completion of reconditioning. It should be definitely understood that these figures do not represent the average cost of repairing defective hydrants in the distribution system, but merely the cost of reconditioning hydrants removed from the system for reasons other than their being defective.

In Milwaukee, no definite economic life period for hydrants has been established, but all hydrants installed prior to 1915 are now retired whenever they become defective or damaged. Some hydrants installed approximately 75 years ago are still in service. Twenty-five of the cities reporting have no established life period, but 7 reported using 75 years for such purposes. When immediately and efficiently done, repairs can greatly extend the life of a hydrant. It is therefore desirable that all defective hydrants be reported immediately and repaired as soon as possible.

Conclusion

In general, hydrant installation and maintenance practice in Wisconsin appears to comply with NBFU and AWWA recommendations. It should be gratifying to most of the water departments of that state to know that they are upholding such high standards, which directly contribute to the safety and protection of the people of their community.

References

1. A Survey of Operating Data for Water Works in 1950. *Jour. AWWA,* **45**:583 (Jun. 1953).
2. *Standard Schedule for Grading Cities and Towns of the United States.* Natl. Board of Fire Underwriters, New York (1942); *Jour. AWWA,* **34**: *following p.* 1584 (Oct. 1942).
3. Standard Specifications for Fire Hydrants for Ordinary Water Works Service—AWWA C502. Am. Wtr. Wks. Assn., New York; *Jour. AWWA,* **45**:539 (May 1953).
4. Specifications for Uniform Marking of Fire Hydrants—AWWA C503. Am. Wtr. Wks. Assn., New York; *Jour. AWWA,* **45**:550 (May 1953).

Report of the Committee on Water Works Administration

For the Year Ending December 31, 1953

A report of the activities of the Committee on Water Works Administration for the year ending Dec. 31, 1953, submitted to the AWWA Board of Directors on Jan. 18, 1953, by Wendell R. LaDue, Chairman.

AS outlined on pages 182–84 of the 1952 AWWA *Directory*, the present organization of the Coordinating Committee on Water Works Administration provides for nineteen subcommittees grouped in four classifications. The general committee consists of the chairman, the general chairmen of the four groups, and the chairmen of the various active subcommittees. Other members of the various subcommittees are not members of the Committee on Water Works Administration. Committee work has been broadened by the creation of "task groups," subordinate to standing committees. The chairman of a task group is not a member of the Committee on Water Works Administration, but, in general, works within the province of the division under which the task group functions. When the work of the task group covers activities in various divisions, however, the chairman becomes a member of the committee. The present committee personnel are:

W. R. LaDue, *Chairman*

F. C. Amsbary	M. P. Hatcher
L. E. Ayres	A. P. Kuranz
J. J. Barr	D. L. Maffitt
M. B. Cunningham	L. A. Smith
R. J. Faust	A. A. Ulrich
E. L. Filby	W. V. Weir
L. S. Finch	

H. E. Jordan, *ex officio*

Personnel and Organizational Changes

Committee activities and personnel have been given considerable study, resulting in the following changes, additions, and reallocations:

A1.A—Constitutional and Statutory Aspects of Municipal Water Works Organization. This subcommittee was inactivated, thereby relieving C. E. Moore, its chairman, of committee duty.

A2.E—Safety Practices. Following authorization by the Board, this subcommittee will be enlarged by the addition of J. E. Hickman and H. L. Roose.

A3.D—Water Main Extension Policy. Following authorization by the Board, this committee will be enlarged by the appointment of A. R. Davis, S. T. Anderson, and J. H. Murdoch Jr.

A4.D—Water Use. The May 1953 meeting of the Board authorized the consolidation of the work of A4.D1—Industrial Water Use and A4.D2—Domestic Water Use under the chairmanship of H. E. Hudson Jr.

A4.F—AWWA Task Force to Cooperate With NARUC Committee on Proposed Rules and Regulations Governing Water Services. This task force was authorized at the May 1953 meeting of the Board and has been organized under the chairmanship of J. H. Murdoch Jr.

Inactive Subcommittees

The following subcommittees are now inactive or have not been activated:

A1.A—Constitutional and Statutory Aspects of Municipal Water Works Organization

A1.E—Taxation and Revenue Allocation

A2.B—Management Relations

A3.A—Construction, Equipment, and Material Contracts

A3.B—Valuation and Depreciation

A3.C—Cost Trends

A4.A—Water Department Reports (adviser retained)

A4.C—Joint Administration of Water and Sewer Facilities (adviser retained).

1953 Conference

At the 1953 Conference, twelve principal topics stemming from the committee's activities, either directly or indirectly, were presented at the various sessions:

Subcommittee Activities

The continuing and growing interest in the field of water works management is evidenced by the steady flow of inquiries into the Association's headquarters regarding committee activities. These questions cover a wide variety of subjects, indicating a need for increased activity in all phases of the committee's present field and expansion into other fields, as the Association program will permit.

The following is a brief summary of the activities of the several subcommittees during 1953:

A1.B—Radio and Mobile Communication Facilities for Water Works. The survey on radio use by water departments reported at the 1952 Conference was continued. Since that time about 50 additional departments have begun using radio. A steady growth in the use of radio by water department management can be expected. Manufacturers were approached and requested to keep on making contact

Committee	Work	In Journal
WWA	Open meeting: General discussion of the activities of the various subdivisions	—
A1.C	Report: The Problem of Air-Conditioning Water Use	Aug. 1953, p. 867
A1.C	Paper: Demand Charge for Air-Conditioning Use in Arkansas	Aug. 1953, p. 870
A1.E	Panel: The Highway Improvement Problem	—
A2.A	Panel: Promoting Better Understanding of What Works Service Is Worth	Oct. 1953, p. 997
A2.B	Report: Status of Training Courses and Certification in the United States	Sep. 1953, p. 971
A2.E	Report: A Safety Program for the Water Works Industry	Sep. 1953, p. 952
A3.D	Paper: Main Extension Policy at Grand Rapids	Jul. 1953, p. 694
A3.D	Report: Water Service for Suburban Areas	Jul. 1953, p. 697
A3.D	Paper: Control of Water Pressure in Suburban Distribution Lines	Nov. 1953, p. 1123
A4.B	Report: Determination of Water Rate Schedules	Mar. 1954, p. 187
A4.D1	Report: Water Conservation in Industry	Dec. 1953, p. 1249
A4.E	Report: Proposed Revision of Utility Accounting System	Oct. 1953, p. 1090

with water works organizations. Liaison was maintained with the National Committee on Utilities Radio. It is proposed to have a water department representative at all regional and national meetings of this committee. The committee has continued the program to show substantial savings and higher performance by the use of radio-equipped cars. The AWWA committee has been especially active in its efforts to maintain equality for water works in the assignment of frequencies in the utility field.

A1.C—Water Use in Air Conditioning and Other Refrigeration. At the 1953 Conference the committee asked to be inactivated until some new development arises demanding specific analysis and action. Inactivation seemed premature, however, and the committee continued its activities, especially in discussions with manufacturers, looking toward an overall national study of the problem. It is believed that a proper understanding of the impact of air conditioning upon "load growth" is yet to be clearly attained.

A1.D—Water Use in Fire Prevention and Protection. The committee is reviewing the data required by the National Board of Fire Underwriters and has scheduled a panel discussion at the 1954 Conference. Thereafter the committee will be in a position to establish a continuing program, embracing rate classifications, evaluation, and coverage.

A2.A—Public Relations. Routine assistance to the AWWA staff in preparing *Willing Water* has continued to be made available. As the Board has given consideration to requesting the US Post Office Dept. to issue a stamp for the seventy-fifth anniversary of the Association, this committee's personnel have been active in laying the groundwork for the project. The Association has produced a picture booklet depicting the advancement and value of public water supplies, and a reprint of the 1946–47 series, "Silent Service Is Not Enough!" in brochure form is under consideration. Although these may not be regarded clearly as committee projects, they are a vital force in public relations and require committee assistance and collaboration.

A2.C—Compensation of Water Works Personnel. The committee submitted a final report reaching the following conclusions, based on the results of a 1951 questionnaire: [1] salary schedules for administrative and engineering positions are available from studies by the American Society of Civil Engrs. and the American Society of Professional Engrs.; [2] no effective work on a *national* basis can be done on salaries for construction, operation, and office employees; and [3] fixing of compensation is only a part of the problem—dignifying of the water works profession is a compensation to be developed by a public relations program. The Association is now undertaking a survey of employment conditions, which may be useful in directing future activities of this committee.

A2.D—Pension and Retirement Plans. Pressure continues to be exerted to place state pension systems under the Federal Social Security Act. National attitudes toward all types of pension systems will affect the water works field and merit close attention.

A2.E—Safety Practices. The main activity of the four task groups of this committee has been the preparation of a safety manual for water utilities. After some correspondence among the sixteen members of the task groups (A2.E1—Supply; A2.E2—Treatment

and Pumping; A2.E3—Distribution; and A2.E4—Administration), an outline of the content of the safety manual was determined. The subject matter is divided into three chapters: [1] the need for a safety program; [2] accident prevention program; and [3] safe practices. Chapter 3 is subdivided into 46 subjects, which cover practically all the activities of a water utility. The material is to be concise and clear, and for the most part positive in nature. It will describe how to perform jobs and handle tools safely rather than explaining what should not be done. Plans are being made, also, to include many pictures and sketches to illustrate safe techniques, complemented, of course, by appropriate statements on safety by "Willing Water." It is tentatively planned to prepare a manual with a maximum of 96 pages. Present schedules call for completion of the job during 1954. All writing assignments have been made, and the first rough draft of the text should be available by March 15. The manual will be developed to make it applicable to small, as well as large, water utilities. Safety in water works is creating very great member interest and more active participation than any other phase of water works personnel management. The committee shows excellent interest and activity.

A3.D—Water Main Extension Policy. This committee has been continuously active. An excellent report was presented at the 1953 Conference, with special consideration to suburban main extensions. With the population trend producing suburban development, this report was particularly timely. Public service commission policies on main extensions will be watched closely. The fact that, in addition to the committee report, two papers on this subject were presented at the 1953 Conference indicates the importance of this subject to water works management. It will be of increasing interest.

A4.B—Water Rates. A report of this committee is published in the March 1954 JOURNAL (this issue, page 187). The committee deserves high commendation for completing an arduous and lengthy job.

A4.D—Water Use. The two task groups (A4.D1—Industrial and A4.D2—Domestic) have been combined. This subject, especially industrial use, reuse, and disposal, is of growing importance. The lowering of the ground water table and the possible pollution of both surface and underground supplies by "used" industrial waters is of vital concern to water works management. The activity of Committee A4.D should be increased, the personnel of the committee being reviewed and strengthened.

A4.E—AWWA Committee to Cooperate With NARUC Committee on Revision of System of Accounts for Water Utilities. A report of this committee was submitted at the 1953 Conference. The committee's approach to the problem is excellent.

A4.F—AWWA Task Force to Cooperate With NARUC Committee on Proposed Rules and Regulations Governing Water Services. On Oct. 8, 1953, copies of the rules and regulations under consideration by the NARUC Committee on Engineering were submitted to the AWWA Board of Directors as a report of committee progress.

Recommendations

The attention of the Board is directed to the need for enlarging the activities of the Committee on Water Works Administration along several

lines. With this in view, it is recommended that the following subcommittees be activated:

A1.E—Taxation and Revenue Allocation. Taxation and revenue allocation, always vital subjects to those in water works management, have become more so in recent years, with superhighway construction requiring large expenditures of water works revenue without the usual increase in capital value. The Association has been able to "nail to the post" exaggerated releases concerning the proportion these costs bear to total highway expenditures. Likewise, the growing tendency toward indirect taxation of water works funds for general city expenses affords much food for discussion. The effect of such procedures upon water rates is by no means incidental. This committee, with Committees A3.D and A4.B, covers a live and active field in water works management.

A4.D—Water Use. The continuing problem of water use and allocation is of national importance. For several years this matter has been handled by task groups. It is believed that the time has arrived for careful consideration to fix the scope of this group. It is recommended that the task group be raised to committee status, with its chairman a member of the Committee on Water Works Administration.

There are numerous Water Works Administration Committee projects that cannot be carried on efficiently strictly on a subcommittee basis. They involve a large amount of research and could best be handled as AWWA staff projects. The Association budget might be supplemented by outside funds, especially when the project involves items in which manufacturers or industries are vitally concerned. The subcommittee activities which might be considered as staff projects are: A1.A—Constitutional and Statutory Aspects of Municipal Water Works Organization (this suggestion was made in the 1952 report); A1.C—Water Use in Air Conditioning and Other Refrigeration; A2.C—Compensation of Water Works Personnel (the survey of employment conditions by the AWWA staff may be a preliminary investigation in this field); and A4.F—Rules and Regulations (like A1.A, this is a vital subject but not suitable for a nationwide formula; both require research at the state level).

At the May 1953 meeting of the Board, the question of scheduling the open meeting of the committee on the first or last full day of the conference was discussed. It is felt that scheduling it in the midst of other conference activities is not in the best interest of the membership. The Program Committee has this matter under advisement.

A review of the action of the Board in discharging the Task Group on Training Conferences and Certification and reappointing it as a committee of the Board is requested. This subject is primarily one of administration and, it is believed, may be within the scope of the Water Works Administration Committee, possibly under A2.B—Management Relations.

Report of the Committee on Water Works Practice

For the Year Ending December 31, 1953

A report of the activities of the Committee on Water Works Practice for the year ending Dec. 31, 1953, submitted to the AWWA Board of Directors on Jan. 18, 1953, by Louis R. Howson, Chairman.

A TOTAL of 391 members of the Association, organized in 46 committees and twelve task groups, were working under the jurisdiction of the Committee on Water Works Practice in 1953. It may appropriately be remembered that this coordinating committee was first set up by George W. Fuller in 1920. From its beginning it has served to channel the productive energy of the Association's membership in voluntary committees working for the benefit of the water industry. During the 33 years since its inception, there have been only three chairmen of this committee—George W. Fuller, Malcolm Pirnie, and the present incumbent. This report covers the progress made during 1953.

C100 Series—Cast-Iron Pipe. Standardization is at a pause, with six ASA A21 standards for water pipe and three for gas pipe completed in 1952 and 1953. The revision of the Manual for the Computation of Strength and Thickness of Cast Iron Pipe—ASA A21.1–1939 (AWWA C101–39) remains pending.

It is also proposed to develop a new standard for water pipe fittings to supersede the AWWA–NEWWA C100 document. These specifications, first promulgated in 1908, were republished in 1952 with a series of corrections in the tables. The 1952 revision was made with the cooperation of the Cast Iron Pipe Research Assn., but, since the document was published, discrepancies have been disclosed to which attention had not previously been called. Accordingly, a very careful revision of the 1952 tables and dimensional drawings is in progress, and the new material will be criticized, prior to publication, by every agency that could conceivably have valid information upon the subject.

C200 Series—Steel Pipe. The section of the Specifications for Cement-Mortar Protective Coating for Steel Pipe—C205–41 relating to field application of coating was withdrawn by official action Jan. 1, 1951. As of Dec. 31, 1953, the text of the "Tentative Standard Specifications for Cement-Mortar Lining in Place of Water Pipe 16 in. and Over" was transmitted by H. Arthur Price, Vice-Chairman, Steel Pipe Committee. This document requires approval by the Water Works Practice Committee before it can be considered by the Board and published. As presently drawn, the specifications may be used to govern the relining of either steel or cast-iron water pipe in place. Committee A21 was invited to share in the preparation of the text but declined. It was made plain, however,

that the document, when prepared by the Steel Pipe Committee, would be reviewed by A21 in a cooperative spirit and with the intention to assist in making the final text fully useful.

C207—Steel Pipe Flanges. The specifications presented in the first report of this committee were approved and published in October 1952. The committee, under the chairmanship of H. O. Hill, is developing standards for flanges for pipe sizes larger than 48 in. No other steel pipe documents have been revised during 1953.

The *Steel Pipe Manual,* which R. E. Barnard has had in preparation for several years, is approaching its final form. Plans for publication will be fully outlined by memorandum to the Officers and Directors when such action is indicated.

C300 Series—Reinforced Concrete Pipe. Specifications for Reinforced Concrete Water Pipe—Noncylinder Type, Not Prestressed—C302 were advanced to Standard in May 1953. The earlier documents, C300 (Steel Cylinder Type, Not Prestressed) and C301 (Steel Cylinder Type, Prestressed), were revised and made Standard in June 1952.

A modification of C301–52 has been proposed by the working committee. It has been found that, under certain conditions, there are advantages in encasing the steel cylinder within concrete to form the core and winding the wire around the concrete exterior of the core rather than forming the core by placing a concrete lining within the cylinder and winding the wire around the cylinder, as now specified. This modification in the manufacture of prestressed cylinder pipe permits making satisfactory pipe in sizes larger than those covered currently by C301; also, the method offers distinct advantages in constructing the larger sizes now covered by C301, that is, 42–54-in. pipe. (Negative votes on the proposed changes by members of the Committee on Water Works Practice have led to deferment of action upon this document. Discussion of the matter will proceed.)

It should be noted that there is presently a worldwide discussion of the failure of a prestressed reinforced concrete pipeline at Regina, Saskatchewan. There is current litigation between the contractor and the city over the rejection of the pipe. It should also be noted that the production of the pipe did not follow any one of the AWWA specifications. It should further be noted that no comparable failure has occurred when reinforced concrete pipe was produced in conformity with AWWA specifications.

C400—Asbestos-Cement Pipe. After negotiations and discussions which were carried on intermittently for more than 10 years, specifications for asbestos-cement pipe *for underground service* were approved and published as Tentative in the July 1953 JOURNAL. Approval of the text as published obligates the working committee to continue its efforts to clarify certain sections of the text before it is advanced to Standard status.

C500—Gate Valves. The Tentative Specifications for Gate Valves for Ordinary Water Works Service, published in the September 1952 JOURNAL, are subject to further exploration before advancement to Standard. There are open questions concerning: [1] the composition of the bronze stem when exposed to high-pH water; and [2] certain details of geared valves. It is hoped to answer these questions during

1954, so that the document can be made Standard.

C501—Sluice Gates. This committee has been reactivated with Charles H. Capen as chairman. The other members of the committee are: D. M. Belcher, J. C. Detweiler, H. W. Griswold, D. D. Gross, V. C. Lischer, N. G. McDonald, and Leslie Paul.

C502—Fire Hydrants. The specifications as revised were approved in March 1953 and published in the May 1953 JOURNAL. They became effective as the basis for purchase on Sep. 1, 1953. The same text, with certain additions involving hydrants used for private fire protection service, is now proposed for adoption by the National Fire Protection Assn.

C504—Butterfly Valves. (The number "C504" has been assigned in advance.) A new committee, headed by Fred G. Gordon, was set up in mid-year 1953 to develop specifications for this increasingly useful type of unit. The first draft of the specifications is in circulation among the committee membership, and a report of progress is scheduled for the technical sessions at the 1954 Convention. In addition to Chairman Gordon, the members of the committee are: G. E. Arnold, J. B. Drab, R. E. Hemborg, D. W. Hopkins, W. A. Kunigk, R. J. Saar, E. A. Schmitt, and R. W. Sawyer.

C600—Installation of Cast-Iron Water Mains. A new section, "Directions for Installing Mechanical-Joint Pipe," has been prepared and will be added to the text when fully approved.

A special research project has been devoted to asbestos yarning material by the Black Labs., Gainesville, Fla. It has shown that, not only is the asbestos not a favorable site for bacterial growth, but the product as fabricated contains enough excess alkaline material to be bacteriostatic for organisms of the coliform group. A specification for asbestos pipe-yarning material is needed, and one will be prepared for AWWA promulgation. The American Society for Testing Materials has a specification for asbestos yarn (ASTM D299–52T) for use in the textile industry.

Following the rejection by the US Dept. of Commerce of the proposed commercial standard for treated jute, the processors have made no effort to carry on the discussions. Jute therefore remains a nonacceptable material for yarning bell-and-spigot water pipe. The ASTM has issued a specification for twisted or braided jute (ASTM D739–52) for use in the textile industry. It contains no references to the sanitary quality of the jute.

No developments have occurred that indicate the propriety of making changes in the references to sulfur jointing compounds as they appear in the Specifications for Installation of Cast-Iron Water Mains—AWWA C600. This document, published in December 1949, remains Tentative and should continue so at least for the year 1954.

C601—A Tentative Procedure for Disinfecting Water Mains. This valuable document, first published in 1947, was revised, approved in March 1953, and published in August 1953. The text had been scrutinized by many informed individuals before it was approved. As it now stands, it is a well balanced series of directions which, if followed, will assure the delivery of safe water through newly installed or repaired water mains. The procedural document has been published along with an interpretative statement by

Marshall P. Crabill, who so competently carried on the studies and discussions related to the revised text.

C700 Series—Meters. The Committee on Meter Specifications was reactivated during 1953, with James G. Carns of the American Water Works Service Co. as chairman. The committee will concern itself with two major questions. The first will be the development of a recommended standby order for the US Dept. of Commerce to issue if it becomes necessary to restrict the use of critical materials. The restriction order which was approved in January 1951 has recently been rescinded by AWWA, as the controls under National Production Authority procedure expired on Jul. 31, 1953. The second phase of the committee's activity will be a revision, where desirable, of the current specifications issued by AWWA.

In addition to Chairman Carns, the "consumer" members of the committee are: M. B. Cunningham, A. P. Kuranz, W. E. MacDonald, H. W. Niemeyer, G. C. Sopp, W. V. Weir, and Henry Wilkens. The NEWWA representatives are: Reeves Newsom, F. S. Brainard, and R. H. Ellis. The Manufacturers Advisory Committee consists of: R. R. Anderson (Worthington-Gamon), H. F. Barrett (Buffalo), W. B. Cambridge (Hersey), F. G. Hundley (Neptune), J. E. Johnston (Badger), and J. F. O'Grady (Rockwell).

D101—Recommended Practice for Inspecting and Repairing Steel Water Storage Tanks, Standpipes, Reservoirs, and Elevated Tanks. This document was revised and approved as Tentative in May 1952. It was advanced to Standard in May 1953.

D102—Recommended Practice for Painting and Repainting Steel Water Storage Tanks, Standpipes, Reservoirs, and Elevated Tanks. This document was revised and approved as Tentative in May 1952. It was further revised in June 1953.

H. O. Hill, Chairman, Working Committee on Steel Water Storage Tanks, represents AWWA on the Steel Structures Painting Council. This organization has just developed and published Volume 1 of the *Steel Structures Painting Manual,* with the title "Good Painting Practice." The text covers surface preparation of steel, quality control of paints, and shop painting in fabricating plants, as well as painting of bridges, water tanks, pipelines, and industrial plants. The text is useful as background material for AWWA specifications for painting water tanks and for protective coating of steel pipelines.

Water Resources Division Committees and Task Groups

E2.A—Weather Control. The chairman of this task group will conduct a survey of legislative proposals and action in the various states prior to the 1954 Convention and will report at that time. The technical program at the 1954 Convention will include one session devoted to weather observation and weather control.

President Eisenhower, on Dec. 9, 1953, appointed a National Advisory Committee on Weather Control, consisting of Chairman Howard T. Orville, Capt., US Navy (Retired), Long Green, Md.; Joseph J. George, Atlanta, Ga.; Lewis W. Douglas, Sonoita, Ariz.; Alfred M. Eberle, Brookings, S. D.; and Kenneth C. Spengler, Arlington, Mass.

E3.A—Watershed Protection and Erosion Control. Chairman Burton S. Grant presented a general statement concerning the subject at the 1953 Convention (published in the August 1953 JOURNAL). No special activity is at present in progress.

E4.A—Deep Wells. In 1952 there was added to the Standard Specifications for Deep Wells—A100–46 a section on "Sealing Abandoned Wells." No criticism or comment has been received which would lead to changes in the added section, and it was therefore advanced to Standard in July 1953.

E4.C—Underground Waste Disposal and Control. The second report of this task group was published in the December 1953 JOURNAL. The group holds the opinion that its function has been completed. The officers of the Water Resources Division do not agree, believing that pollution of ground water is still a serious problem; that many states do not yet exercise effective control over such pollution; and that more organized investigation and publicity must be carried on before the concern of AWWA with the problem can be satisfied.

Water Purification Division Committees and Task Groups

E5.B—Manual of Water Quality and Treatment. Three special task groups were organized late in 1951 to bring up to date the chapters on aeration, mixing and sedimentation, and filtration. The task groups have their work well in hand and some of it nears completion.

During 1953 the Sanitary Engineering Div. of the American Society of Civil Engrs. proposed that ASCE Manual 19 on water filtration be rewritten, jointly with AWWA. Ray L. Derby, who has been chosen by ASCE to head the work, proposes to associate himself with the chairmen of the three AWWA Task Groups mentioned above and embody, in the new Manual 19, the fruits of their work. It appears proper to consider that ASCE Manual 19 was, in its first edition, and is proposed also to be in its second edition, a manual of *design*. The AWWA *Manual of Water Quality and Treatment* is primarily concerned with operation, both in theory and practice. There appears to be a reasonable basis for joint action in revising Manual 19, and discussions on procedure have been carried on. [The Board has approved the joint enterprise.]

TABLE 1

Specifications for Water Purification Chemicals

Specification	In JOURNAL	Made Standard
B200—Sodium Chloride	Mar. 1950	May 1953
B201—Soda Ash	Feb. 1952	May 1953
B202—Lime	Jan. 1953	
B250—Cation Exchanger Test Procedures*	May 1949	May 1951
B300—Hypochlorites	Oct. 1953	
B400—Ammonium Sulfate	Nov. 1950	May 1953
B401—Bauxite	Jul. 1950	May 1953
B402—Ferrous Sulfate	Oct. 1950	May 1953
B403—Alum	Nov. 1952	
B404—Ferric Sulfate	in hands of referee	
B405—Sodium Aluminate	in preparation	
B406—Silicates for Activated Silica	in preparation	
B500—Trisodium Phosphate	Jun. 1950	May 1953
B501—Caustic Soda	Dec. 1951	May 1953
B600—Activated Carbon	Feb. 1951	May 1953
B601—Sodium Pyrosulfite	Jan. 1954	
B602—Copper Sulfate	in hands of referee	
B701—Sodium Fluoride	Sep. 1950	revision pending
B702—Sodium Silicofluoride	approval pending	
B703—Fluosilicic Acid	final draft submitted	

* This is not a specification for the material.

E5.1—Specifications and Tests for Water Purification Chemicals. This committee is under the general direction of James E. Kerslake. Twelve documents had been published by the end of 1953; one was included in the

January 1954 JOURNAL; one more is under revision; the approval of a new document is pending; and five more are in process (see Table 1).

E5.6—Specifications for Filtering Materials. The committee document, B100, was briefly revised, approved in June 1953, and published in July 1953.

E5.7—Potable-Water Storage Reservoirs. The year 1953 brought to a conclusion the 5-year task of appraising the limitations of open-air storage and formulating a report covering the protection of both open and covered water storage reservairs (published in the October 1953 JOURNAL). To E. L. Bean goes great credit for bringing to a conclusion the work initiated by N. J. Howard. The assignment was a difficult one. The development of the final text involved not only broad understanding of the problem but also the use of great care in emphasizing the values of reservoir cover without condemning existing reservoirs that are not covered and are reasonably satisfactory to the consumers of supplies derived from them. In accordance with a letter-ballot of June 11, 1953, the committee was discharged.

E5.8—Disposal of Wastes From Water Purification and Softening Plants. In the November 1953 JOURNAL, the sixth and final report of the committee (appointed in 1946) was published. The series of reports included:

1. "Lime and Lime-Soda Sludge Disposal," by William W. Aultman (December 1947 JOURNAL)
2. "Brine Disposal From Sodium Zeolite Softeners," by Paul D. Haney (December 1947 JOURNAL)
3. "Disposal of Wash Water From Purification Plants," by Harry R. Hall (December 1947 JOURNAL)
4. "Lime and Lime-Soda Sludge Disposal," by A. P. Black (September 1949 JOURNAL)
5. "Brine Disposal From Cation-Exchange Softeners," by Paul D. Haney (September 1949 JOURNAL)
6. "Disposal of Wastes From Filter Plants and Coagulation Basins," by John B. Dean (November 1953 JOURNAL).

All of these studies and reports are professionally creditable to the committee and to the Association. For the time being, the task is completed and the committee should be discharged. When the third edition of the *Manual of Water Quality and Treatment* is prepared, it will be appropriate to bring up to date and consolidate these separate reports into a single chapter of the manual.

E5.10—Fluoridation Materials and Methods. Charles R. Cox was appointed chairman to replace O. J. Muegge, who requested to be relieved of the chairmanship but expressed willingness to remain as a committee member. Franz J. Maier has been added to the committee. The committee is making a census of additional cities that began the fluoridation of their supplies in 1953.

E5.13—Molecular Filter Membranes. This task group was activated in 1953 with J. E. McKee as chairman. The other members are: R. L. Derby, R. E. Noble, Lee Streicher, and Alexander Goetz. The task group worked very diligently and completed its report in time for publication in the November 1953 JOURNAL.

The Water Purification Division set up two new task groups in 1953:

E5.14—Survey of State Regulation on Water Treatment Plant Design. Personnel have not yet been selected.

E5.15—Effects of Synthetic Detergents on Water Supplies. Paul D. Haney has been appointed chairman. The other members of the task group are: R. L. Culp, J. D. Enright, W. D. Hatfield, H. E. Lordley, and J. C. Vaughn.

Each of these two groups faces an important study. The effect of synthetic-detergent wastes in streams has become very serious in England and is beginning to manifest itself in various parts of the United States. High-level and prompt study of this problem is essential.

Joint Commitees

J1—Standard Methods. The preparation of the tenth edition of *Standard Methods for the Examination of Water, Sewage, and Industrial Wastes* has not been fully completed. All material is in the hands of the correlating editor, and publication is expected by midyear 1954. The delays in completion have been occasioned by the fact that a more complete reexamination and revision of the text than customary has been made. The forthcoming edition, for the first time, includes among the sponsors the Federation of Sewage and Industrial Wastes Assns., which joins the American Public Health Assn. (the original sponsor) and AWWA (cosponsor since 1925).

J2—Joint Boiler Feedwater Research Committee. This interassociation activity, set in motion many years ago by Sheppard T. Powell, is sponsored by six organizations. Its present leadership is principally in the mechanical engineering and boiler-manufacturing field. Its activities center about high-pressure boiler operations and related problems.

J10—Intersociety Corrosion Committee. This committee, which is staffed and coordinated by the National Assn. of Corrosion Engrs., acts as a clearinghouse for information concerning studies of corrosion carried on under the leadership of various societies and associations in North America. The committee meets once each year and issues a consolidated report annually.

J16—Backflow Preventers. This is a joint committee of AWWA and the Conference of State Sanitary Engrs., organized during 1952 to consider the performance of backflow preventers. Although there was active interest in this field before the committee was established, no work has yet been done by the joint group. Representing AWWA are Andrew T. Dempster, Richard H. Ellis, and Ray L. Derby. Representing CSSE are Paul J. Houser, E. C. Meredith, and C. I. Sterling Jr.

J20—Joint Committee on Chlorine Supply. This interassociation and interagency group, under the chairmanship of Warren J. Scott and with R. J. Faust as secretary, completed its first major project during 1953, a report on "Recommended Procedures in the Use of Chlorine at Water and Sewage Plants," published in the October 1953 JOURNAL.

ASA Committees

The AWWA is represented on a group of committees operating under ASA jurisdiction. The record of their 1953 activities follows:

B58—Deep Well Turbine Pumps. The AWWA is the sponsor for this project, which includes representatives from nine associations and federal agencies. A final report was sent to

committee members in June 1953. Three conferences have since been held, and final action is set for early 1954.

A13—Scheme for the Identification of Piping Systems. A proposed revision of the committee document was submitted in August 1953. It appears that the document will be approved and published during 1954.

B16.5—Steel Pipe Flanges and Fittings. A final revision was submitted in October 1953 to a board of review, was approved by ASA, and was published in December 1953.

B31—Code for Pressure Piping. The current document was published in 1951. Supplement No. 1 was submitted to committee members in March 1953.

K61—Storage and Handling of Anhydrous Ammonia and Ammonia Solutions. At a meeting on Mar. 31, 1953, revisions of certain sections were discussed and approved. The chairman was instructed to prepare a redraft and submit it to the committee members. No final action has been reported.

Y1—Standardization of Abbreviations. No activity was reported during 1953.

Y10—Letter Symbols. Proposed standards for radio were submitted in June 1953. Proposed standards for acoustics were submitted in October 1953.

Y32—Graphical Symbols and Designations. Proposed standards for electrical diagrams were submitted in July 1953 but have not yet been issued.

Z4.2—Standards for Drinking Fountains. A revision of the 1942 standard was submitted in May 1953. The text has not been finally approved.

Z48—Marking Compressed Gas Cylinders. No activity was reported during 1953.

Consideration is being given to the organization of a joint AWWA–ASCE committee on spillway design and capacities.

Consideration is also being given to a special task group study of the service rendered by tar enamel bituminous coating applied to the inside of steel pipe. The Cast Iron Pipe Research Assn. is at present supporting research looking toward the development of a more satisfactory coating for cast-iron pipe to take the place of the current bituminous or previous coal-tar dip. A study of breaks in cast-iron pipe has previously been authorized and it is seriously hoped that it will be undertaken during 1954.

Standardization

There are two aspects of standardization activities which merit consideration. One is the method of study and approval of all working-committee documents by the Water Works Practice Committee and the Board of Directors. The second is the necessity of study of standards by the membership and the propriety of formally filing comments and suggestions for revision with the Secretary of the Association and, through him, with the Correlating Committee and the appropriate working committee.

The "AWWA Standardization Procedure," which was most recently published in the 1953 Reference Edition of the AWWA *Directory* (pages 21–26), merits careful study by all who serve on committees or task groups and also by the membership at large. The organization and approved operating routine of working committees are outlined in Article 3 (pages 22 and 23) and should be familiar to every committee member.

After a working committee has completed its work on a standard or a recommended procedure, it is filed with the Secretary and by him with the Committee on Water Works Practice for its approval. After approval by the Water Works Practice Committee, the document must be approved by the Board of Directors before it can be published as an Association standard.

It must be understood that working committees are selected carefully so that the group as a whole is especially well informed on the subject assigned to it. With the basic competence which the members of any working committee have, there can be no question that their knowledge of the subject matter of their study and report is better than that of the Correlating Committee or the Board of Directors. Why then should not a working committee's recommendations be accepted without further ado and published as an Association standard? The answer, in brief, is that it is better to catch an error before it becomes public. Errors once public are very difficult to overcome. It must also be understood that the working committee is not always unanimous in its final recommendation of specifications. It frequently takes months, and even years, for a committee to come forward with a report for which there can be a substantial majority acceptance.

The membership of the Water Works Practice Committee is carefully selected with a view to competence in the widely diversified fields covered by all the working committees. Sometimes the Water Works Practice Committee's discussion indicates a means by which a specification under consideration can be improved. Such suggestions are communicated to the working committee and frequently are adopted. The end result that the water works industry have the best possible specifications is thereby promoted.

The routine of approval seldom fails to develop questions, which, when answered, result in a clarification of the document. The further fact that the fifteen members of the Water Works Practice Committee and the 40 members of the Board are required to study such documents gives broad assurance that no detail of a proposed standard is given undue or incorrect emphasis.

In earlier years all standards had to be approved at *meetings* of the Water Works Practice Committee and the Board. Discussion in open meetings often produces understanding that letter-ballots cannot produce. Thus, the standardization procedure requires that, in a meeting, two-thirds of the Board shall approve; but, when a letter-ballot is employed, eight-tenths of the entire Board membership (32 out of 40) must approve. Hence, when a committee makes a report that may be subjected to special study and deferment of final action until an open discussion is held in a meeting, the released document must be considered more to the credit of the committee than it would be if it had not run the gauntlet of critical examination.

Those who observe its work consider that the standing of AWWA in the technical field is rising. The care taken to scrutinize its standards is to the credit of AWWA and all its working committees. The very evident desire of manufacturers of water works components to be able to base the sale of their products upon AWWA standards is a further tribute to the work done by its committees.

The second aspect of standardization work that merits consideration is the need for study, comment, and criticism of a document after it has been published. All standards, when first developed or revised, must remain tentative for at least a year. This probationary period is established to give the members of the Association who purchase or operate in accordance with specifications or procedural documents an opportunity to question the meaning of sentences or paragraphs or to discover some practical error or deficiency in the document as published.

For example, the revised specifications for gate valves were published in September 1952. Only one member of AWWA has filed any questions concerning the document. Can it be so nearly perfect? How many of those who distribute a lime-softened water have taken into account the note in the text which points out that bronzes with high zinc content deteriorate in such water much more rapidly than low zinc content bronzes?

Are the 1953 specifications for fire hydrants considered perfect? Surely someone should be able to find an error in the text. No one has yet said so, however.

This statement is a plea for a more critical attitude on the part of the Association's members. Improvement grows out of constructive criticism. Comments, when indicated, should be filed with the Secretary of the Association. He, in turn, will transmit them to the appropriate person or persons. Such action on the part of the membership will help the industry.

Report on Publications

For the Year Ending December 31, 1953

A report on the publishing activities of the Association for the year ending Dec. 31, 1953, submitted to the AWWA Board of Directors on Jan. 18, 1953, by Eric F. Johnson, Asst. Secretary—Publications.

DURING 1953 a revised advertising section format permitted a reduction in the overall size of the JOURNAL, even while the number of pages devoted to technical articles was being significantly increased. In this way, it was possible to give members more JOURNAL content at the same time as an adjustment was being made to hold down expenditures in the face of ever increasing costs of printing and production and the threat of reduced advertising income. Sales of all books declined, in some part for lack of any special advertising, but the availability of the new cast-iron pipe standards pushed specifications sales to record highs that increased overall publication receipts 33 per cent over 1952. Meanwhile, too late in the year to affect income, two new booklets, which promise to be exceptionally popular and profitable, were issued. With at least two new manuals in prospect and the tenth edition of *Standard Methods* now well on its way, the future holds promise of even greater expansion of the Association's publication activities.

1. The Journal

a. *Contents.* Despite an increase of 160 pages of technical articles, the total number of JOURNAL pages was reduced to 2,560 in 1953 from 2,608 in 1952. It was a limited program of facing advertisements, together with space economies in the handling of abstracts and other "Percolation and Runoff" material, that was primarily responsible for the 15 per cent cut which brought the advertising section down from 1,390 pages in 1952 to 1,182 last year. The other factor was a slight drop in advertising insertions.

In the revised format, text pages during 1953 totaled 1,378, compared with 1,218 in 1952, restoring to its prewar size the JOURNAL's selection of technical articles and information. Included in this selection were a total of 139 items, 33 of them AWWA and other official documents or reports and 106 of them technical articles—21 from the Annual Conference, 61 from section meetings, and 24 from other sources. The fact that the number of articles published represents a reduction from 121 in 1952, in the face of a 13 per cent increase in space allocated, is less a measure of long-windedness than of the tendency toward panel discussions, which found 178 authors collaborating on the 106 articles. Then, too, the 122 pages devoted to the "Survey of Operating Data for Water Works in 1950" and its analysis consumed a considerable portion of the additional space.

The abstracts section suffered a decrease, though not as serious as the reduction from 146 to 85 pages would seem to indicate. Part of that differ-

ence is the result of a reduction in type size and an increase in the width of the column used. Thus, the actual change was 23 pages—still a serious loss which, it is hoped, can be made up during 1954.

b. *Cost.* Despite the 48-page reduction in size, the JOURNAL cost approximately 7 per cent more in 1953 than it did in 1952. Primarily, the increase was the result of higher printing prices —an average rise of 4 per cent. But the increase in the number of copies printed, averaging approximately 400 more than the 11,189 of 1952, and the very expensive typesetting involved in publishing the "Survey of Operating Data" are also reflected in the rise.

Working at the end of the year under a printing price index of 201.2 and a paper cost index of 196.9 (based on 1943 rates), the Association was paying an average of 47.5 cents per copy for a JOURNAL that averaged 217 pages per issue in 1953, compared with 45.9 cents per copy for 221-page issues in 1952. The cost per 1,000 pages of printing also rose, from $2.071 in 1952 to $2.185 in 1953, the largest increase since 1949. Reflected in these unit costs, together with the rise in printing rates, is the expensive typesetting mentioned above, as well as the generally greater expense of text over advertising section material; the text section now accounts for 54 per cent of the pages as against only 47.7 per cent in 1952.

For 1954, with the 2 per cent printing price increase of last September applied for the full year and with increases in paper and engraving prices in prospect, a budget of $69,500—only $1,500 more than the 1953 budget, but approximately $3,500 more than actual 1953 expenditures—is proposed.

c. *Income.* With advertising insertions taking a slight dip, JOURNAL income leveled off during the year. Compensating for the 2.6 per cent drop in insertions (from 879 pages in 1952 to 856 in 1953), the effect of the first full year at the 1952 rate schedule was to bring income up to the 1952 figure—$85,167.00 in 1953 compared with $85,146.50 in the previous year. But this was almost $2,500 short of the $87,500 anticipated. Meanwhile reprint income was down 12 per cent, to $4,899.45; but nonmember subscription income was up by the same proportion. Income from that portion of member dues allocable to JOURNAL subscriptions, of course, had another banner year, owing to a net growth of 543 members.

Whether or not the slight pause in advertising growth means anything more than pauses in the past is difficult to say. The fact that other publications in the field have experienced somewhat similar setbacks may indicate that it does. On the other hand, with so many people looking so hard for signs of recession, it is almost impossible not to see some. It was with this situation in mind, however, that the Executive and Finance committees approved holding the 1954 rate increase to less than 10 per cent, instead of the 15 per cent originally tied in with the 18 per cent increase in circulation. At any rate, contract receipts for 1954 advertising have been encouraging enough to support an estimate of $90,000 for the year.

d. *The future.* For further in the future, other plans for the JOURNAL are being considered. First, for 1955, the possibility of using pictures of authors on the first page of articles is being explored, with the thought of providing greater recognition to authors and more human interest and a more attractive makeup for the JOURNAL. Also, in view of the fact that the contents page has now been moved up

to the first page of the issue, a return to the use of the picture cover, discontinued in 1950, is being considered. The only real objection to the picture cover used in 1949 was the fact that it made it too difficult to find articles, as the contents were then listed among the advertisements on page 11. This objection was overcome in the revision of the advertising section format last year. The use of author pictures would add approximately $500 to the production cost of the 1955 JOURNAL, and the use of cover pictures another $250. Although a final decision on these matters can be postponed till September 1954, the Board's early consideration and comment will be appreciated.

For the more indefinite future, thought is being given to the possibility of breaking up the JOURNAL into two publications—one, on the order of *Civil Engineering,* to include news, abstracts of papers, special features, Association affairs, and advertising, and the other to include complete papers as presented at section meetings and conventions. Advantages suggested for the splitup are that it would provide an attractive, newsworthy publication offering the kind of material that members would be inclined to read upon arrival, thereby also providing a vehicle for such material as is now included in *Willing Water, Defense News,* and other letters and bulletins issued by the AWWA office. The thought is, of course, that this publication would be in the 9×12-in. size that is more attractive to advertisers, thus boosting advertising income enough to pay for the *Proceedings,* which would issue on a quarterly basis as a record of solid accomplishments in the field. On the other hand, such a splitup would undoubtedly reduce the readership of the serious articles. And, though it would probably increase income in selling more—and more expensive—advertising, it would certainly also necessitate considerably greater expense for an enlarged staff, as well as for the enlarged publications.

On the whole, the justification of such a change would have to lie in greater service rather than in a better financial position, and it would carry with it the very definite possibility that expansion of service would have to be accompanied by an increase in what have long and widely been considered AWWA's low membership dues. A great deal of careful study is required to weigh the advantages and disadvantages of such a proposal.

2. The Directory

The first Reference Edition of the *Directory,* which included such items as the Association Constitution, By-Laws, and related documents, the Buyers' Guide, the Directory of Consultants, and an interim list of new and reinstated members, was issued with the September 1953 JOURNAL. Although it had been planned to split the *Directory* material into two equal sections, this first odd-year issue was just a little more than half as large as the 1952 membership list edition—136 pages, compared with 256. By shifting the committee lists into the next odd-year issue and by some consolidation of present membership listings, it is expected to make the two editions a little closer in size in the future.

With the wide discrepancy in size and in the type of material included, the two editions are difficult to compare. It is interesting to note, however, that with total costs at $8,527 and $4,415, respectively, for the 1952 and 1953 issues, costs per 1,000 pages were also lower in 1953—$2.56, compared with $2.70. The higher print-

ing and paper prices of 1953 were more than offset by the less expensive typesetting involved in producing the reference material. Adding the 35.8-cent cost per copy of the 1953 edition to the 70.3 cents per copy of the membership list, the total cost of publishing the 392 pages of combined *Directory* was considerably higher than the 71.2 cents it had cost for the 320-page issue of 1950. It is noteworthy, however, that the net cost per copy of the combined 1952 and 1953 issues was only 35.7 cents, compared with the 37.9 cents per copy that the 1950 issue cost under much lower printing rates. The difference, of course, arises from the fact that two sets of advertisements are possible with the annual issues; although the $3,840.50 realized from the sale of advertising in the 1953 *Directory* fell short of the $4,500 budget, it did bring the net cost per copy down to a mere 4.7 cents. Moreover, as advertisers become familiar with the idea of annual editions, insertions are expected to increase.

For 1954, when the membership list edition is again to be published, a budget of $9,500 appears necessary, in view of the $8,500 cost of the comparable 1952 edition and the increases in both membership and prices since then. Advertising income is again estimated at $4,500, with the expectation that the habit of *Directory* advertising will begin to be formed with this edition.

3. Specifications

During 1953 specifications for centrifugally cast iron pipe, for a mechanical joint and pressure fittings for cast-iron pipe, for asbestos-cement pipe, for fire hydrants, for lime, and for hypochlorites, as well as a procedure for disinfecting mains, were approved and published in the JOURNAL. In addition, specifications for pit-cast iron pipe and for cement-mortar lining were materially revised, although not republished in full. All were made available in reprint form.

It was particularly the completion of the series of ASA-approved cast-iron pipe specifications that occasioned a tremendous 1953 demand, boosting sales of specifications to $16,693.02, more than double the 1952 figure of $7,428.68, which, in turn, was more than double the 1951 total of $3,603.74 —an almost unbelievable record of growth. With a total of 50 standards documents now available and more to be issued in the coming year, it is expected that sales will continue strong, although, with the original demand for the cast-iron pipe documents satisfied, income is expected to drop to the $10,000 level for 1954.

Included in the specifications sales figures for the past few years have been specifications binders, of which the remaining stock of 142 was sold during the year. This item is being discontinued because of the handling and shipment problems it created and the local availability of satisfactory substitutes.

4. Journal Indexes

In 1953, 32 copies of the 1881–1939 index were sold, leaving a balance of 132 copies in stock. Meanwhile, sales of the 1940–44 supplement reduced the stock of that item to 25 copies, enough to satisfy demands until a substitute is in closer prospect. During the year, work on a 1940–54 index was advanced sufficiently to assure that the bulk of the job will have been completed by the end of this year, making publication early in 1955 possible.

5. Standard Methods

During 1953, despite the imminence of a new edition, more than 1,750 copies of the ninth edition of *Standard Methods for the Examination of Water and Sewage* were sold, requiring two additional printings and pushing sales of that volume to more than 21,000 copies in 7 years. Total copies in stock at the end of the year were 120, less than a month's supply at the 1953 rate of sales. No decision concerning further reprinting has yet been made.

Work on the tenth edition is proceeding rapidly. The manuscript of the water chemistry section was given a preliminary styling and editing and then duplicated for final committee review during the early part of the year. Then, following further revision based on the review, it was forwarded to the editorial coordinator for integration with the other sections of the book. Now, with a printer selected and the design of the book set, the water section is in the hands of the American Public Health Assn. editorial staff for final marking for the printer. If all goes well, the tenth edition will appear in the latter part of 1954.

6. Accounting Manual

During the year 32 copies of the *Manual of Water Works Accounting* were sold, the big drop from the 152 copies of 1952 being due primarily to lack of promotion. A special effort will be made during 1954 to increase sales from the stock of 568 copies now on hand.

7. Survival and Retirement Book

Sales of *Survival and Retirement Experience With Water Works Facilities* also fell off during the year, 51 copies being sold, compared with the 162 of 1952. Stock now on hand includes 206 bound copies and 1,000 unbound.

8. The Quest for Pure Water

In 1953, 52 copies of *The Quest for Pure Water* were sold, a drop from 140 copies in 1952. This left a stock of 506 bound and 491 unbound copies.

9. Water Quality and Treatment

Sales of 425 copies of the second edition of *Water Quality and Treatment* during 1953 reduced the stock of this volume to 1,294 bound and 4,800 unbound copies. With a continuing demand from college bookstores and the planned stimulation of other demand through special promotion, it is expected to reduce this stock considerably before work on the publication of a third edition must be undertaken.

10. British Manual

Following the cessation of the intensive promotion of 1952, sales of the *Manual of British Water Supply Practice,* for which AWWA is American agent, fell off precipitously, from 507 copies in 1952 to 19 in 1953. It is hoped to sell out the remaining 35 copies in stock through some special promotion during 1954.

11. Willing Water

In its first year of regular bimonthly issuance, *Willing Water* presented 48 pages of information on such varied topics as safety, rapid tests for toxic materials, fluoridation, and the utility relocation problem, in addition to its basic message of public relations. During 1954 it is expected to continue this publication schedule, presenting material of the same basic nature. Expenditures for 1953 were approximately 10 per cent below the $6,000 budgeted. With publication costs dependent upon

the type of material presented and the possibility of distribution with other Association mailings, however, the same budget is recommended for 1954.

12. Your Water Supply

The booklet, *Your Water Supply,* was designed for distribution by water utilities to their customers as a public relations aid. Giving information on how to read meters, how to detect and repair leaks, and how to save water, the booklet is offered, imprinted with the utility's name, primarily for use as an envelope stuffer.

Announced in the October issue of *Willing Water,* the booklet had piled up orders for more than 120,000 copies, most of them in 1,000 and 2,000 lots, by the end of the year. The cost of the typesetting was charged to *Willing Water,* as the text was first used there, but that cost and much more will be made up in the margin cleared on reprints, despite the fact that prices were held to a minimum. Sales during the coming year have been conservatively estimated at $3,500; beyond that, sales should remain steady for years, because the booklet promises to be of continuing value as a public relations tool.

13. The Story of Water Supply

Sent to the Board during the year in one of its early drafts, the picture booklet, *The Story of Water Supply,* was mailed to all members in what may wistfully be designated "the December 1953 mailing." Delays on route from Cleveland, where it was printed, unfortunately held up the mailing, but by mid-January 1954 the booklet was in the hands of all members.

Designed primarily for distribution by water utilities to their junior customers through local school systems, the booklet promises also to serve a variety of public relations as well as public information purposes. The $2,000 original cost of development has already been paid to the printer, and an additional bill of perhaps $300 is expected to cover what the printer has termed "excess alterations," resulting from the special care with which the various drafts of this publication were scrutinized and corrected. From the spot-check indication that 25 selected utilities could use as many as 150,000 copies, the $5,000 income budgeted for 1954 may seem conservative, but the booklet may take some time in gaining acceptance. At any rate, it is felt that this item will be a long-time best seller among Association publications.

14. Manuals

Suggestions for various Association manuals have been considered during the year. Two for which definite estimates have been made are the reprinting of "Silent Service Is Not Enough!" and the proposed safety manual. Another which will be issued during 1954, primarily as a reprint of a JOURNAL article, is the water rates manual, scheduled to include extracts from the classic literature of the field as an appendix to the committee report itself. All will be useful additions to the list of AWWA publications.

Another suggestion being considered is the combination of key articles in various branches of the field to make a series of manuals on important subjects—for instance, collections on valve maintenance and repair, on meter maintenance practice, on billing and accounting, and on legal problems. Such manuals could be of great help, particularly to the small water works operator, who must be a master of all trades. Before recommendations can be made, further study of the economics of the suggestion must be undertaken.

Report of the Audit of Association Funds

For the Year Ending December 31, 1953

To the Members of the American Water Works Association:

The By-Laws require that the Secretary have an audit made annually of the books of the Association.

The records for 1953 have been examined by the staff of Louis D. Blum & Co. The complete record of that examination follows.

Audits have been published in the JOURNAL annually. Since 1942 they have appeared in the March issue.

Respectfully submitted,
HARRY E. JORDAN
Secretary

January 26, 1954

TO THE AMERICAN WATER WORKS ASSOCIATION:

We have examined the balance sheet of the American Water Works Association as of December 31, 1953, and the related statements of income and surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet as of December 31, 1953, and the related statements of income and surplus present fairly the financial position of the American Water Works Association at that date and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed)

LOUIS D. BLUM & CO.
Certified Public Accountants

EXHIBIT A—BALANCE SHEET

DECEMBER 31, 1953

Assets

Cash in Banks and on Hand		$ 47,912.19
Accounts Receivable:		
Advertising—Journal	$4,647.50	
Reprints	327.45	
Manual—Water Quality and Treatment	40.00	
Sundry specifications	539.40	
Other	300.08	5,854.43
Membership Dues		569.97
Accrued Interest on Bonds		417.57
Inventories:		
Paper stock	5,063.21	
Type metal	1,925.70	
Cumulative Index	158.40	
Quest for Pure Water—Baker	1,514.25	
Survival and Retirement (book)	1,128.06	
Manual—Water Quality and Treatment	4,341.00	
Manual of Water Works Accounting	846.32	
Manual of British Water Supply Practice	217.00	
Your Water Supply (booklet)	1,028.02	
Sundry specifications	2,668.35	
Back issues—Journals—Vol. 1–45, inclusive (49,983 copies)	—*	
Back issues—Proceedings—1881–1913, inclusive (248 copies)	—*	18,890.31
Office Equipment (less depreciation)		9,776.87
Investments at Cost (Schedule 1)		113,540.00
Deferred Expenses		2,619.67
Deposit—Airlines		425.00
TOTAL ASSETS		$200,006.01

Liabilities and Surplus

Accounts Payable	$ 928.68
Membership Dues—Advance Payments	45,719.42
Unearned Subscriptions to Journal	4,066.18
Payable to American Water Works Association Pension System	20,000.00†
Reserve for Award Fund (McCord)	53.02
Senior Members Contributory Fund	592.00
Surplus, per Exhibit C	128,646.71
TOTAL LIABILITIES AND SURPLUS	$200,006.01

* Back issues of Journals and Proceedings are inventoried but no money values are assigned to them for balance sheet purposes inasmuch as the entire costs were charged off during the year of publication. The quantity shown is in accordance with a tabulation supplied by the Association's printer.

† Secured by assignment of the income of US Savings Bonds, Series G, and maturity redemption value of such bonds in the amount of $20,000.

EXHIBIT A, SCHEDULE 1—INVESTMENTS

DECEMBER 31, 1953

Description	Interest Rate %	Principal Amount	Cost	Quoted Market or Redemption Value Dec. 31, 1953
Foreign Securities:				
Province of Ontario	4	$ 1,000.00	$ 732.50	$ 1,052.50*
Dominion of Canada, 6th Victory Loan	3	2,000.00	2,000.00	1,983.75†
Hydro Electric Power Commission of Ontario	2.75	5,000.00	5,075.00	4,918.75†
Province of Ontario	3	2,000.00	2,022.50	1,832.50†
Hydro Electric Power Commission of Ontario	3	2,000.00	2,020.00	1,970.00†
Dominion of Canada, 9th Victory Loan	3	5,000.00	4,775.00	4,831.25†
United States Securities:				
US Savings Bonds, Series:				
G	2.5	10,000.00	10,000.00	9,730.00‡§
G	2.5	10,000.00	10,000.00	9,610.00‡§
G	2.5	2,000.00	2,000.00	1,972.00‡
G	2.5	5,000.00	5,000.00	4,910.00‡
G	2.5	2,000.00	2,000.00	1,946.00‡
G	2.5	10,000.00	10,000.00	9,700.00‡
G	2.5	3,000.00	3,000.00	2,901.00‡
G	2.5	10,000.00	10,000.00	9,610.00‡
G	2.5	2,000.00	2,000.00	1,922.00‡
G	2.5	5,000.00	5,000.00	4,790.00‡
G	2.5	2,000.00	2,000.00	1,916.00‡
G	2.5	7,500.00	7,500.00	7,117.50‡
G	2.5	2,500.00	2,500.00	2,377.50‡
G	2.5	1,000.00	1,000.00	962.00‡
K	2.76	5,000.00	5,000.00	4,960.00‡
US Treasury Bills		20,000.00	19,915.00	19,946.00
			$113,540.00	$110,958.75

* This security is payable in United States funds.
† These securities are payable in Canadian funds. Market value represents value in New York in United States funds.
‡ These amounts represent redemption value on Dec. 31, 1953.
§ Redemption value and income of these securities assigned to American Water Works Association Pension System.

EXHIBIT B—STATEMENT OF INCOME AND EXPENSES

FOR THE YEAR ENDED DECEMBER 31, 1953

Operating Income:

Annual dues	$98,176.52	
Advertising—Journal	85,167.00	
Advertising—Directory	3,840.50	
Subscriptions to Journal	6,797.95	
Convention registration fees	19,934.00	
Convention—other events	874.09	
Water and Sewage Works Manufacturers' Assn	7,500.00	
Interest on investments	2,802.08	
Miscellaneous interest income	6.74	
TOTAL OPERATING INCOME (carried forward)		$225,098.88

TOTAL OPERATING INCOME (brought forward)		$225,098.88
Publication Income:		
Manual of Water Works Accounting	214.40	
Reprints	4,899.45	
Cumulative Index	101.20	
Membership Certificates	39.00	
Proceedings and Journals	1,707.10	
Quest for Pure Water—Baker	268.75	
Survival and Retirement (book)	151.55	
Manual—Water Quality and Treatment	2,053.04	
Manual of British Water Supply Practice	210.00	
What Price Water (booklet)	55.48	
Sundry specifications	16,552.48	
One-half of profit from sales of Standard Methods (book)	3,431.46	
Miscellaneous income—Cast-Iron Pipe Specifications	3,685.00	
TOTAL PUBLICATION INCOME		33,368.91
TOTAL INCOME (carried forward)		$258,467.79

Operating Expenses:

Directors' and Executive Committee Meetings:

Travel expense	$ 7,077.44	
Stenographic expense	244.00	$ 7,321.44

Administrative Expenses:

Rent	10,000.00	
Office supplies and services	12,992.98	
Membership promotion	463.60	
Pension—Secretary Emeritus	2,500.00	
Contribution to pension system	4,802.70	
Legal and accounting expenses	1,795.17	
General and special travel	1,113.51	
Federal activities	1,209.80	34,877.76
Administrative Salaries		73,123.58
Committee Expense		1,090.98

Division and Section Expenses:

Section—membership allotment	17,416.40	
Section—official travel	4,485.44	
Section—general expense	726.63	22,628.47

Journal:

Printing	47,035.87	
Production	4,893.80	
Paper	14,088.16	
Abstractors	146.74	
Directory	4,415.53	70,580.10
OPERATING EXPENSES (carried forward)		$209,622.33

TOTAL INCOME (brought forward)			$258,467.79
OPERATING EXPENSES (brought forward)		$209,622.33	
Convention:			
General	6,451.87		
Entertainment	9,876.56	16,328.43	
Membership Dues in Other Associations		1,107.50	
Depreciation of Office Equipment		1,588.91	
Miscellaneous Expenses		285.94	
TOTAL OPERATING EXPENSES		$228,933.11	
Cost of Publications Sold:			
Manual of Water Works Accounting	$ 26.63		
Reprints	3,767.30		
Cumulative Index	39.60		
Membership Certificates	17.60		
Proceedings and Journals	27.47		
Quest for Pure Water—Baker	158.83		
Survival and Retirement (book)	94.86		
Manual of British Water Supply Practice	140.30		
Manual—Water Quality and Treatment	898.79		
Standard Methods (book)	853.54		
Sundry specifications	7,518.21	13,543.13	
Development Activities:			
Public relations	5,297.19		
Story of Water Supply (picture booklet)	2,000.00		
Research promotion	2,321.91		
Research—asbestos packing	850.00		
Survey of Operating Data for 1950	500.00	10,969.10	
TOTAL EXPENSES			253,445.34
Net Income for the Year (transferred to Exhibit C)			$ 5,022.45

EXHIBIT C—SURPLUS FOR THE YEAR ENDED DECEMBER 31, 1953

Balance, January 1, 1953	$123,624.26
Add: Net income for the year, per Exhibit B	5,022.45
Balance, December 31, 1953, per Exhibit A	$128,646.71

American Water Works Association Pension System

BALANCE SHEET—DECEMBER 31, 1953

Assets

Cash in bank	$ 1,500.12
Accrued bond interest	554.35
Investments (Schedule 1)	80,000.00
TOTAL ASSETS	$82,054.47

Liabilities and Reserve for Future Benefits

Liability for refund of employees' contributions plus earned interest	$ 5,326.58
Reserve for future benefits	76,727.89
TOTAL LIABILITIES AND RESERVE	$82,054.47

SCHEDULE 1—INVESTMENTS, DECEMBER 31, 1953

Description	Interest Rate %	Principal	Maturity Date
Bonds Registered in Name of Administrative Committee:			
Series G	2.5	$10,000.00*	1961
Series G	2.5	10,000.00*	1962
Series G	2.5	14,000.00*	1963
Series K	2.76	9,000.00*	1964
Series K	2.76	4,000.00†‡	1965
Series K	2.76	10,000.00†§	1965
Series K	2.76	3,000.00†‖	1965
Bonds Registered in Name of Association and Assigned to Administrative Committee:			
Series G	2.5	10,000.00	1956
Series G	2.5	10,000.00	1958
		$80,000.00	

* Redemption value on Dec. 31, 1953: $41,229.00.
† Acquired in 1953.
‡ Not redeemable until Feb. 1, 1954.
§ Not redeemable until Mar. 1, 1954.
‖ Not redeemable until Jun. 1, 1954.

STATEMENT OF RECEIPTS AND DISBURSEMENTS FOR THE YEAR 1953

Item	Cash	Reserve for Future Benefits	Liability for Refund of Employees' Contributions
Receipts:			
Association contributions	$ 4,802.70	$ 4,802.70	
Employees' contributions	1,492.03		$1,492.03
Interest on bonds	1,765.05	1,765.05	
Redemption of Series G bond	10,000.00		
Total	18,059.78	6,567.75	1,492.03
Disbursements:			
Investment in Series K bonds	17,000.00		
Refund of contributions plus interest	705.48		705.48
Audit and legal expense	50.00	50.00	
Office expenses	6.00	6.00	
Total	17,761.48	56.00	705.48
Excess of Cash Receipts Over Disbursements	298.30	6,511.75	786.55
Adjustments for Non-Cash Items:			
Interest credited to employees' accounts		(94.05)*	94.05
Interest accrued on bonds, Jan. 1, 1953		(416.25)*†	
Interest accrued on bonds, Dec. 31, 1953		554.35‡	
Total		44.05	94.05
Additions to accounts for year	298.30	6,555.80	880.60
Balance, Jan. 1, 1953	1,201.82	70,172.09	4,445.98
Balance, Dec. 31, 1953	$ 1,500.12	$76,727.89	$5,326.58

* Deduction.
† Accrued interest receivable as per balance sheet Dec. 31, 1952.
‡ Accrued interest receivable as per balance sheet Dec. 31, 1953.

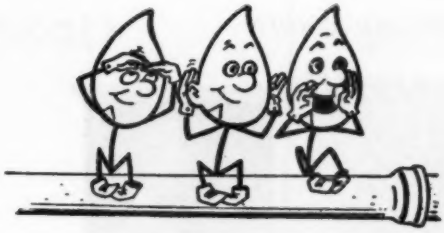
AWWA Membership Growth

Membership Statement—Year of 1953

	Active	Corporate	Munic. Serv. Subscriber	Associate	Honorary	Junior	Affiliate	Total
Total members, Dec. 31, 1952.....	7,452	832	153	348	37	46	49	8,917
Change of grade, 1953.....	19	−1	1	—	2	−20	−1	
	7,471	831	154	348	39	26	48	8,917
Gains:								
New, 1953.....	941	65	35	16	—	16	4	1,077
Reinstated, 1953.....	75	15	5	2	—	—	2	99
	8,487	911	194	366	39	42	54	10,093
Losses:								
Resignations and deaths, 1953 ..	−237	−13	−1	−9	—	−1	−2	−263
Dropped for nonpayment, 1953..	−329	−31	−4	−2	—	−1	−3	−370
TOTAL MEMBERS, Dec. 31, 1953...	7,921	867	189	355	39	40	49	9,460
Net gain in 1953.....	469	35	36	7	2	−6	—	543

Comparative Statement—Gains and Losses—25-Year Period

Year	New	Reinstated	Resignations and Deaths	Suspended for Nonpayment of Dues	Gain or Loss	Total Members at End of Year
1929	314	25	118	130	91+	2,547
1930	501	39	122	134	284+	2,831
1931	203	22	123	216	114−	2,717
1932	117	22	169	297	327−	2,390
1933	168	56	159	234	169−	2,221
1934	271	66	86	122	129+	2,350
1935	565	42	85	190	332+	2,682
1936	311	53	104	218	42+	2,724
1937	515	86	122	139	340+	3,064
1938	520	59	144	140	295+	3,359
1939	578	64	122	179	351+	3,710
1940	514	58	113	212	247+	3,957
1941	480	92	116	236	220+	4,177
1942	570	59	132	233	264+	4,441
1943	769	88	130	198	529+	4,970
1944	734	92	140	171	515+	5,485
1945	543	56	111	235	253+	5,738
1946	816	79	168	324	403+	6,141
1947	933	74	143	349	515+	6,656
1948	847	81	207	347	374+	7,030
1949	1,083	75	196	323	639+	7,669
1950	852	58	128	421	361+	8,070
1951	1,090	63	199	441	513+	8,583
1952	1,005	66	232	505	334+	8,917
1953	1,077	99	263	370	543+	9,460



Percolation and Runoff

To be all wet is to be all set these days in a world that the doom-boomers contend is drying into extinction. Worrying over the warming of our winters and pointing to the drought after drought after drought that has been extending its area from Texas to Africa, from Brazil to New England, the more calamitous of our prophets are predicting a swift aridification of our present centers of population and progress, a drying up and blowing away of our present water-blessed world. Meanwhile, others of our experts, remembering how many ends our world has already survived, have busied themselves with developing the means of surviving the increasing use of our allegedly decreasing supply of available water. Radar, weather modification, sea-water distillation, water spreading, and, on the very grandest scale, water resources conservation are all the objects of more and more serious study, even to the point, now, of rating special Congressional appropriations.

All this attention, both bad and beautiful, has, of course, been of tremendous benefit to the field in creating a better public appreciation of the value of water supply. Almost suddenly, we are not even surprised when the Pittsburgh *Press* gives top headlines to a $10,000,000 water main repair program that will tighten up the city's system; we become almost blasé about water supply appreciation editorials, even when they appear simultaneously in such separate places as the Providence (R.I.) *Evening Bulletin* and the Salt Lake City *Tribune;* we almost forget to mention that water supply has been a top issue in elections in New Jersey, Texas, California, and New York; we scarcely realize that the linage of water supply stories in the nation's press must have increased a thousandfold in the last ten years. Realizing it now, we can realize, too, how much more emphasis has been placed on frightening than on enlightening and get to work reaping the benefits before present appreciation sours into notoriety.

Adequate appreciation adequately exploited ought to mean adequate rates and adequate support of projects designed to provide an adequate supply. Just what these various "adequacies" add up to may be a little difficult to define, but, certainly, if water supply is to hold its own with the other utilities, an adequate supply can be no less than all the water every customer wants at any time. And lest there be concern about losing such a publicity prize as the imminence of disaster, it is our thought that the achievement of adequacy must raise rates to a level at which customers would appreciate water even without the danger of losing it!

To be all set is to be all wet whatever the weather!

(Continued on page 34 P&R)

(Continued from page 33 P&R)

Tiernan, Wallace, and a dream

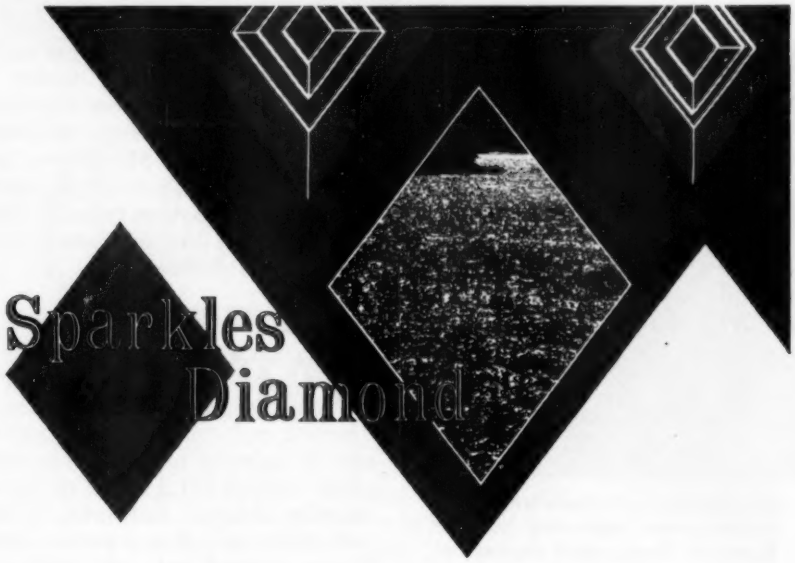
New Wallace & Tiernan officers include F. G. Merckel (top) as president, and R. M. Jackson (left) and C. D. Peet (right) as vice-presidents.

The torch is handed on as Wallace, Tiernan, and Orchard retire from active service and Merckel, Jackson, and Peet carry on. The two young men pictured above joined forces in 1909 to bring into being their dream of a device which the water works industry awaited. Many men active today do not realize that the first decade of this century found our leaders demanding standards of water quality that could not be met until chlorination made it possible. Then it was only a few years until Orchard, with his missionary spirit and energy, had spread the gospel far and wide.

Orchard: start of a mission

In retirement, these three men are by no means decrepit, but they know of many corporations whose leaders have waited too long to let the younger men take over. Thus the Wallace & Tiernan tradition will be carried on by F. G. Merckel as president; R. M. Jackson, executive vice-president; and C. D. Peet, vice-president in charge of engineering and development. Responsible to Mr. Merckel in staff capacities will be: H. C. Marks, director of laboratory research; David Crampton, chief chemical engineer; J. C. Cornwall, secretary of the corporation; and T. T. Quigley, assistant to the president and operational analyst.

(Continued on page 36 P&R)



With adequate dosages of Aqua Nuchar, water leaving your plant will be palatable and also give the appearance of sparkle that is appealing to the eye. Besides removing the unpleasant odors, treatment of water with Aqua Nuchar gives your water that extra something to enliven consumer acceptance.

If you have customer complaints, Aqua Nuchar Threshold Odor Experts will give your plant a complete survey without obligation. They will then recommend how you can best use adequate dosages of Aqua Nuchar to bring your threshold odors down to 5. (Remember that just reducing the threshold odor from 50 to 25 will be detectable *only* by a very keen sense of smell.) The correct amount of Aqua Nuchar will deliver the sparkling, palatable water desired.

Consult with Industrial's Technical Staff about the use of Aqua Nuchar in your water treating plants.

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2775 S. Moreland Blvd.
At Shaker Square
Cleveland 20, Ohio

(Continued from page 34 P&R)

Participating in the installation ceremonies were (beginning at left) Burton S. Grant, chief engineer of water works; George Read, retired meter and service superintendent; Robert A. Heffner, member of the board of commissioners; Mrs. Harry B. Ross, the property owner; Samuel B. Morris, general manager and chief engineer; and (foreground) Bob Luce, service and main foreman. Also present were Max K. Socha, engineer of water distribution; George Sopp, joint system head and assistant manager; and Henry Horandt, Pacific Coast manager of Neptune Meter Co.

Half a million water meters have now been placed in service by the Los Angeles Dept. of Water & Power, which celebrated the event with due ceremony (above). This record-breaking total leaves far behind the nearest contenders: Detroit, with 388,919 meters; Philadelphia, with 329,464; Cleveland, with 248,000; New York, with 192,224; and Chicago, with 124,055. Of these, only Detroit and Cleveland—and, of course, Los Angeles—are completely metered.

Some indication of the rate at which Los Angeles is installing meters is given by the fact that less than four years ago the city installed its 400,000th meter. Except for 319 meters that were in service when municipal operation of the water system began in 1902, the entire total has been installed by the present department.

A record volume of $46.5 billion in construction was completed in the U.S. in 1953, according to a survey made by the Associated General Contractors of America, and continued high activity may be expected in 1954. The total, which includes $11.8 billion for reconditioning existing structures, is high both dollarwise and in physical volume, it was pointed out, and represents nearly 13 per cent of the gross national product of $369 billion, thus indicating that one out of every eight dollars spent for end products and services went for construction.

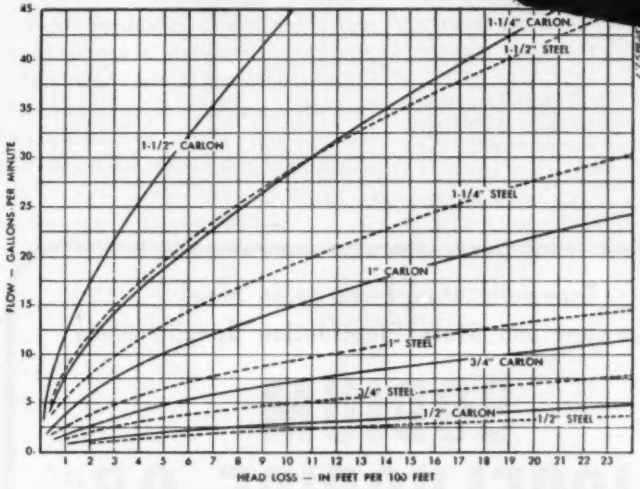
New public construction reached $11.3 billion as records were broken for the second successive year. The outstanding trend in this field, according to AGC, is the expansion of local and state public works—chiefly highways, schools, and sewage and water facilities—to engross nearly 60 per cent of the total public construction.

Frank C. Tolles has retired as a partner in the firm of Havens & Emerson, consulting engineers of Cleveland and New York. He will continue an affiliation with the firm as a consultant. At the same time Frank S. Palocsay and Edward S. Ordway have been admitted to the firm as partners, and Alvin M. Mock and Glen H. Abplanalp have been advanced to the position of principal engineers.

(Continued on page 38 P&R)

Carlon
PLASTIC PIPE
FOR GREATER FLOW

HERE ARE THE FACTS!



FLOW VS. HEAD LOSS IN CARLON PIPE AND STEEL PIPE

Figures revealed in the above graph have been computed by top hydraulic laboratories in the United States. These are the facts . . . fluid flow in any size CARLON Plastic Pipe surpasses flow for the same size of steel pipe. CARLON maintains its Flow Superiority for the life of the pipe.

These are the reasons . . . CARLON'S smooth interior wall prevents "wetting" . . . eliminates adhesion between liquid and pipe surfaces. The combination of smooth surface and non-wetting characteristics create a condition that truly approaches perfect pipe flow.

Today CARLON Plastic Pipe is being used for water service lines, handling of sewage and general low-temperature, medium-pressure applications.

Buy the Pipe with the Stripe!

CARLON PRODUCTS CORPORATION
Pioneers in Plastic Pipe
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Send today for complete facts and figures on head loss in CARLON Plastic Pipe.

(*Continued from page 36 P&R*)

Mesmerization as a substitute for chlorination may sound just a little bit psychoceramic (that's Wendell LaDuvian for crackpot), but, actually, the partial inactivation of *Salmonella typhosa* by hypnotic suggestion has already been seriously reported before an international meeting of microbiologists in Rome. Technique of this rather counterrevolutionary method of water purification involves merely the incantation: "No growth, no growth, no growth. You are sterile, you are sterile. You are dead, you are dead." * But the Ceylon physician who developed the method has reported that comparison of plates of incanted typhoid bacteria with control plates in every case revealed "the mesmerized bacteria grew much less than the others."

Looking for an explanation somewhat more scientific than our initial suspicion that the typhosa were either scared or just bored to death, we were forced to conclude that the good doctor's resonance in incantation must have wrought some sonic, if not supersonic, havoc among the plated bacteria. On the other hand, giving due credit to the mysteriousness of the East and remembering that talk is cheap and water treatment expensive, we're already embarked on a course in Ceylonese—apparently the only typhosa-traumatic tongue. As a matter of fact, we've even taken to drinking tea, though not entirely for the same reason.

* It is understood that *Escherichia coli* are more susceptible to inactivation if subjected to the chagrin of pretreatment with "You stink, you stink, you stink."

(*Continued on page 40 P&R*)

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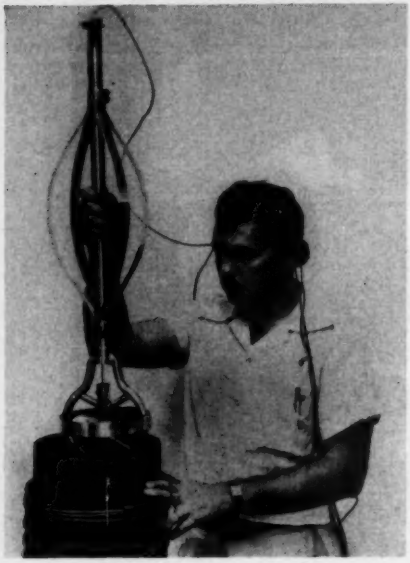
(Continued from page 38 P&R)



A vertical current meter (above) for measuring flow in pressure relief wells behind levees and at the toe of earth dams has been developed by the Waterways Experiment Station of the Corps of Engineers at Vicksburg, Miss. The instrument utilizes commercially available bearings and a contact assembly to give an electrical indication (audible through earphones) of the rate of revolution of the aluminum impeller. Above the impeller a spring leaf assembly keeps the meter centered in the well. Once the meter has been calibrated by counting revolutions for known flows, it is said to give an accuracy of within 3 per cent over a range of 10 to 1,000 gpm.

United States Pipe & Foundry Co. has made a number of changes in its sales and distribution procedure. Agency agreements at Los Angeles and Seattle have been terminated, and company offices opened without change of address in those cities instead. The Los Angeles office is manged by George J. Bogs, who transferred from Chicago; and Robert N. Park of the Hugh Purcell Co., which had held the Seattle agency, has been made Northwestern Sales Agent in charge of the Seattle office.

A new office has been opened at 317 State Tower Bldg., Syracuse, N.Y., and is being managed by J. Perry Emerson, formerly of the Eastern Sales Office, as New York State sales agent. Other appointments made are that of Buddy Amis of the Dallas office to become sales representative at Houston, and L. C. Krusen of the Eastern Sales Office to replace George J. Bogs at Chicago.

(Continued on page 42 P&R)

Filter Sand and Gravel

Well Washed and Carefully Graded to Any Specification.
Prompt Shipment in Bulk or in Bags of 100 lb. Each

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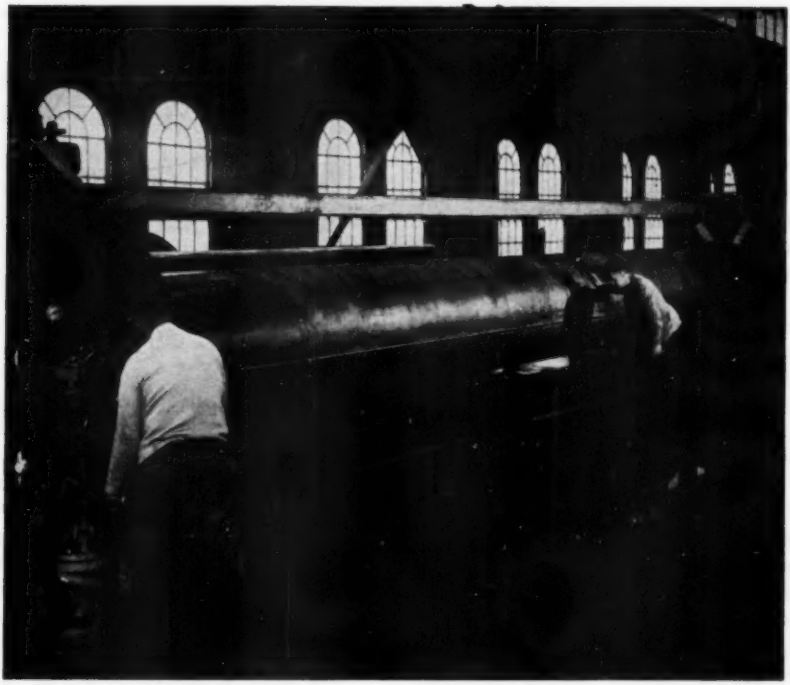


Why You Can Be Sure About the Strength of Steel Pipe

The photograph shows a 40-ft length of Bethlehem Steel Pipe undergoing a hydrostatic test at our Steelton, Pa., plant. This test is carried out in accordance with AWWA requirements, the pipe being subjected to a test equivalent to 200 pct of the working pressure.

Each length of Bethlehem Pipe is tested in this way to prove its strength and water-tightness. In addition, Bethlehem Tar-Enameled Pipe has these worthwhile advantages:

It resists corrosion, because the pipe is lined and coated with a smooth, uniform layer of coal-tar enamel. The lining, being impervious to corrosion and incrustation, ensures high flow-coefficients for the life of the installation.

It is also resistant to water-hammer. It can carry a load of nearly four times the working pressure. In addition, it has the resilience to "give" with soil movement, making it immune to the effects of surface vibrations.

Bethlehem Tar-Enameled Pipe can be joined into a tight, sound line by mechanical couplings, or by welding or riveting. The pipe is generally furnished in 40-ft lengths. It comes in diameters from 22 in. i.d. through 150 in. i.d., and in thicknesses to accommodate any working pressure.

Perhaps you would like to have complete information about Bethlehem Tar-Enameled Pipe. All you need do is drop a line to the nearest Bethlehem office.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM *Tar-Enameled* WATER PIPE

(Continued from page 40 P&R)

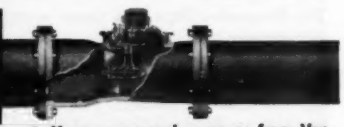
To the hills is where Willing Water was headed last time we saw him—and all because of science. It was bad enough when a friend engineer from Victoria, B.C., tied him into hydraulic knots for the explanation of an apparent exaggeration in his water waste warnings (*see* p. 52 P&R, this issue). But that he was able to slide rule out of relatively unscathed with the aid of that old *D* that equals *CAV*. Now, however, with meteorologists at both the Illinois Water Survey and the University of Chicago vying for priority in making fun of his figure, Willie is really crushed (see cut)—crushed, as a matter of fact, into the shape either of "a small hamburger bun" or "a fat mushroom," depending upon which meteorologist you happen to read. The meatier of the two descriptions comes from the Chicago study which James E. McDonald made for the Air Force, using, first, equations and, then, high-speed photography to check on his aerodynamic calculations. The chubbier view came from Douglas M. A. Jones and Lawrence A. Dean of the Survey, who studied pictures of some 200,000 drops to determine that "the typical big raindrop is almost flat on the bottom and round on the top, whereas smaller drops are just round balls."

Purpose of all this prying into Willie's personal profile was primarily curiosity, though it is now alleged that the information will aid in explaining why and how raindrops break into fragments and the nature of heat and vapor transport at the surface of falling raindrops. We, who much prefer Willie just as he is, are anything but convinced by the explanation. And though scientists of the same meteorological ilk have assured us that Willie's hill climbing won't get him into too much trouble, as water has recently been found unfrozen at heights of 36,000 ft and temperatures of $-60°F$, we're more than a trifle concerned.

Come home, Willie! We love you! You'll not even be the only one we love who needs to wear a girdle.

(Continued on page 44 P&R)

IT PAYS TO SAY
BUILDERS PROPELOFLO



THE MAIN LINE METER manufactured to Builders' traditional quality standards. Accuracy is within 2% over a wide range. Low loss-of-head. As easy to install as a valve or fitting. For Bulletin 380-K4, write Builders-Providence, Inc. (Division of B-I-F Industries, Inc.), 385 Harris Ave., Providence 1, R. I.

- More power and accuracy from Venturi body design
- Clear-view plastic totalizer bonnet
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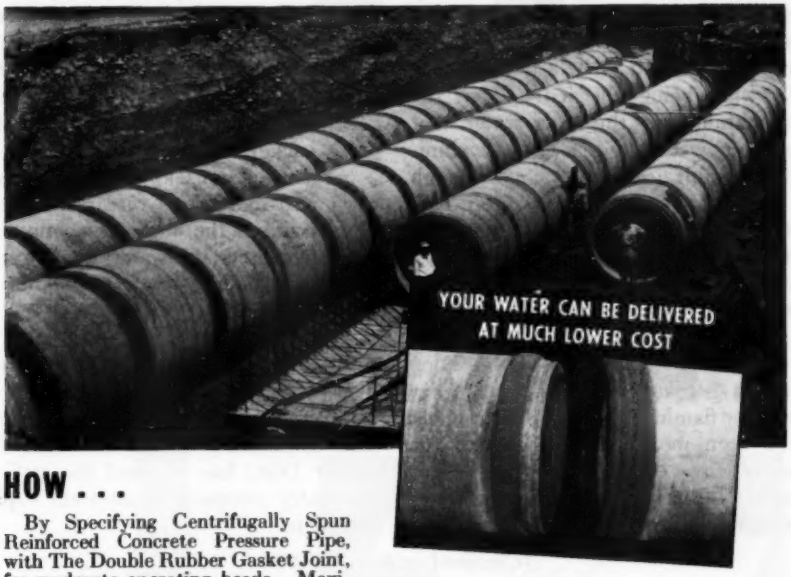
- External grease fitting on ALL models

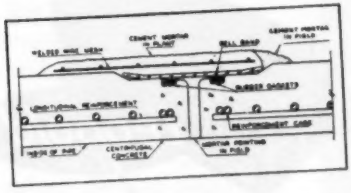
BUILDERS–PROVIDENCE
PIONEERS IN METERS AND CONTROLS

THIS PIPE CAN SAVE YOU MONEY



HOW . . .

By Specifying Centrifugally Spun Reinforced Concrete Pressure Pipe, with The Double Rubber Gasket Joint, for moderate operating heads. Maximum operating heads range from 100 ft. to 150 ft. depending upon pipe diameter and operating conditions.



A watertight closure, simple in design, flexible and positive in service. Joints may be pulled to allow for minor changes in line or grade. Angle joint bands provided for larger deflections. This joint was developed by American to insure ease and speed of installation.

WHY . . .

1. *FREEDOM FROM MAINTENANCE.*
2. *SUSTAINED MAXIMUM CARRYING CAPACITY.*
3. *EASE OF INSTALLATION.*
4. *PERMANENCE.*
5. *LOW FIRST COST.*

Rely on American Pipe and Construction Company's 45 years of know-how in this field. Our experience, our informative booklets and our sales engineers are as near as your telephone.

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(*Continued from page 42 P&R*)

Fire water in ten-gallon lots really elevated the eyebrows of the Wasco County Commission at The Dalles, Ore., last month, when the month's bills were being checked. Even the explanation that this was water that had been wetted didn't entirely eliminate the quizzical expressions, though it did get the bill paid. Too bad, really, that The Dalles is so far from Copenhagen, for at just about that time outside Denmark's capital, a contractor's water wagon, covered with straw to keep the water from freezing, caught fire and burned so hot that firemen couldn't get at the contents to extinguish the flaming exterior. What could have been more convincing than the use of fire water to save a water wagon? And who drinks fire water through a straw?

E. Windle Taylor has been advanced from the post of deputy director to director of water examination for the Metropolitan (London) Water Board, succeeding E. F. W. Mackenzie, retired. Dr. Windle Taylor, who also has a background that qualified him as a barrister [counselor at law], joined the board in 1935 as research bacteriologist and is the author of a number of publications on water quality and analysis, including *The Examination of Waters and Water Supplies.*

L. S. Vance, onetime chief engineer of the Louisville Water Co. and more recently technical adviser to the Louisville & Jefferson County Metropolitan Sewer Dist., has rejoined the staff of the water company as assistant superintendent.

(*Continued on page 76 P&R*)

AMONG WATER WORKS MEN

THE HEAVY-DUTY ELLIS PIPE CUTTER IS *BEST*

FOR CUTTING LARGE SIZES OF PIPE

No. 01 Cuts Pipe 4" to 8"

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Write for circular and price list No. 35J, on our complete line of pipe cutting tools.

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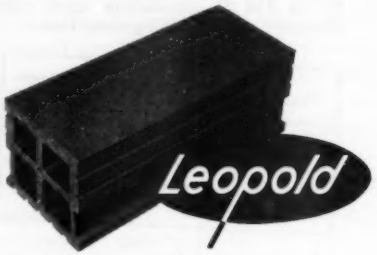

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Tile Filter Bottoms

Successfully serving over 250 plants with a daily capacity of more than 1¼ billion gallons.

Permanent • No corrosion or tuberculation • Equal distribution • Uniform filtration • Low loss of head • Requires only small sized gravel • No metal in contact with water!

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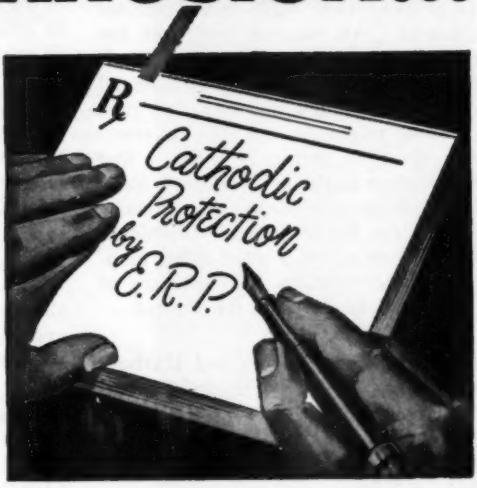
2413 W. Carson Street, Pittsburgh 4, Pa.

℞ FOR CORROSION...



You don't need a specialist to *recognize* Corrosion. But you do need one to treat it successfully. The skill required to achieve complete corrosion control comes only from the knowledge and experience gained through years of practical application.

Recognition of that fact is one reason more and more people are turning to E.R.P. for assistance on corrosion problems—one reason that thousands of buried or submerged steel structures of all types have been successfully protected against corrosion by E.R.P. engineers. Corrosion specialists *for over 17 years*, these men are highly trained and well equipped to help you with *your* corrosion problem. Write for full information today.

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The Reading Meter

An Introduction to Laboratory Technique in Bacteriology. *Max Levine. Macmillan Co., New York (3rd ed., 1954) 413 pp.; $4.50*

Others may be better qualified to attest to the pedagogic value of this text, but the exercise instructions certainly appear clear and straightforward enough, and the fact that this manual has reached its third edition since 1927 seems sufficient testimonial. An unusual topic that has been included is the preparation of culture media without the use of commercial digests. The author observes that such experience might be valuable in emergency situations, but it is probable that such training might be even more valuable in arousing students to appreciate the basis for the ready-made techniques they too often accept without either question or understanding. The glossary of terms should be useful to the student.

Bibliography of Rivers and Harbors and Related Fields in Hydraulic Engineering. *Robert S. Rowe. Rivers and Harbors Section, Dept. of Civil Engineering, Princeton Univ., Princeton, N.J. (1953) 407 pp.*

Intended to serve as the basis for establishing a reference library on river and harbor development, this privately printed volume assembles an impressive array of references. The work is divided into topical sections, and includes some on hydraulic engineering, reclamation, flood dams and reservoirs, water power, and water supply engineering, in addition to those implied by the title. Unfortunately, some of subjects that lie outside the author's main field of interest —such as those with which AWWA is primarily concerned—are either carefully boiled down according to some system which is not readily evident from inspection, or else are given rather superficial treatment. But perhaps this judgment may be attributed to wounded pride, since among the many periodicals which were omitted from the list at the very beginning of the volume, was the Journal AWWA. In good company, be it said, but it stung all the same.

Annotated Bibliography of U.S. Geological Survey Reports on Water-Power Resources Including Floods and Droughts. *Loyd L. Young & Benjamin E. Jones. Circular 200, Geological Survey, Washington 25, D.C. (1953) 32 pp.; paperbound; free*

This compilation provides a serviceable index to the literature (including unpublished manuscripts) produced by the Geological Survey in this field.

Design and Operation of Septic Tanks. *Monograph Series, No. 18. World Health Organization, Geneva (1953) 122 pp.; paperbound; $1.50 from Columbia Univ. Press, 2960 Broadway, New York 27, N.Y.*

This work contains part of the proceedings of the Third European Seminar for Sanitary Engineers, held at London from Oct. 27 to Nov. 1, 1952. Papers by British, German, Swiss, and Belgian contributors discuss such matters as small sewage treatment plants as well as domestic septic tanks themselves. A summary of discussions and a bibliography are included.

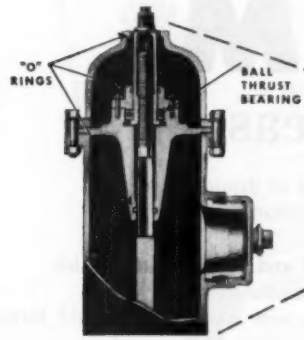
(Continued on page 48 P&R)

In Cuyahoga Falls... Darling hydrants for 45 years ...now DARLING B-50-B's are going in!

EASIER maintenance and rugged construction... basic design advantages of Darling hydrants and valves . . . have been paying off in Cuyahoga Falls, Ohio, since way back in 1908. In the words of City Engineer T. H. Sauter, "The City of Cuyahoga Falls has been a user of Darling hydrants and valves since 1908. The ease with which repairs can be effected has been a factor in the determination of the city to standardize on this type of equipment."

Darling B-50-B's Bring Unique, New Advantages!

Cuyahoga Falls, and hundreds of other cities too, are now installing the new Darling B-50-B hydrants. This dry-top, ball-bearing hydrant opens quicker, operates easier, and eliminates bothersome packing lubrication. Moreover, the special Darling B-50-B "O" rings are insurance against loss of lubricant for threads and bearings . . . *and never let a drop of water reach the operating threads.*



Before you decide on any hydrant or valve, get all the facts on the new Darling B-50-B hydrant and Darling water valves for every service. *Write today!*

DARLING VALVE & MANUFACTURING CO.
Williamsport 23, Pa.

Manufactured in Canada by The Canada Valve & Hydrant Co., Ltd., Brantford 7, Ontario

The Reading Meter

(Continued from page 46 P&R)

Irrigation Development and Public Water Policy. *Roy E. Huffman. Ronald Press Co., 15 E. 26th St., New York 10, N.Y. (1953) 336 pp.; $6.50*

The author, who teaches agricultural economics at Montana State College, has given us a thoughtful and discerning book on the socio-economic aspects of land reclamation and irrigation development. His chapter on "The Public Interest in Water Resources," while failing to give the short-cut answer that so many people pretend to have found, is stimulating and philosophically rather profound—as might be expected, since he goes to John Dewey for his definition and understanding of "the public." It is not at all necessary to agree with the attitudes and opinions the author goes on to express—and disagreement there can legitimately be, aplenty—to recognize that in calling for a consistent, long-term, national water policy, he is making hard sense. In a field in which emotional rhetoric has become almost the recognized type of exposition, this book represents quite an achievement.

Water Resources of the Louisville Area, Kentucky and Indiana. *M. I. Rorabaugh, F. F. Schrader & L. B. Laird. Circular 276, Geological Survey, Washington 25, D.C. (1953) 49 pp.; paperbound; free*

Floods and pollution are the chief problems, as might be expected of a community located along the Ohio River, but the general water supply outlook is favorable, with many sources still untapped.

(Continued on page 50 P&R)

Depend on Cyanamid's
ALUM
for 6 good reasons

1. It feeds uniformly, without trouble, in solid or liquid form.
2. It has a wide pH range for effective coagulation.
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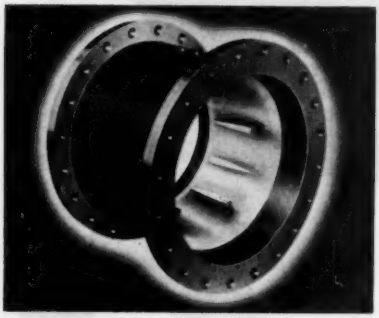

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The Reading Meter

(Continued from page 48 P&R)

Neutralization of Acidic and Alkaline Plant Effluents. *Manual Sheet W-3, Water Pollution Abatement Manual. Manufacturing Chemists Assn., Inc., 1625 Eye St., N.W., Washington 5, D.C. (1953) 13 pp.; paperbound; 25¢*

An enlightened approach to pollution control guides the development of the Water Pollution Abatement Manual, of which this chapter on neutralization is the third to appear. The ways in which acid or alkaline wastes can damage a stream and the life in it are noted, and the mechanics and economies of remedial measures are analyzed. Attention is also directed to the less evident harm done by such pollution: the interference with water or waste treatment, and the damage done to sewers and other equipment.

The two previous chapters are Manual Sheet W-1, "Organization and Method for Investigating Wastes in Relation to Water Pollution" (7 pp.; 20¢); and W-2, "Insoluble and Undissolved Substances" (10 pp.; 20¢), published in 1948 and 1949.

A Guide to Field Training for Sanitation Personnel in Public Health. *William C. Gibson et al. Fourth Annual Report, Subcommittee on Field Training, Committee on Training, Engineering Section, American Public Health Assn., New York (1953) 37 pp.; paperbound; free from W. C. Gibson, School of Public Health, Univ. of Michigan, Ann Arbor, Mich.*

This report attempts to bridge the gap between formal academic preparation and the actual job done by sanitary inspectors, sanitarians, engineers, and public health or sanitary engineers. It proposes a 12-week "interneship" for such personnel and standardizes the aims, methods, and direction of the training they are to receive in this period. Administrative details of the program, including considerations of direction, organization, and financing, are also discussed.

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Correspondence

Watch That Waste Line

To the Editor:

I have just received a copy of the comic book written by our friend, Willing Water. I read the book through and enjoyed it very much and feel that it will go a long way toward explaining to the public the efforts of the water works industry to provide a water supply for the people. However, on coming to the last page, it struck me that Willing Water was exaggerating a little bit in regard to the runoff from a leaky faucet.

A picture of a faucet was shown discharging a $\frac{1}{8}$-in. stream of water. The statement was made that this would produce 2,800 gal of water in 24 hr. If it had been 2,880 gal, it would have been 2 gpm. This struck me as being a little high. I then got out my slide rule and found that the velocity of the stream would have to be 50.6 fps to produce 2,800 gpd of water. I do not think that Willing Water himself could open a tap just enough to produce a $\frac{1}{8}$-in. stream of water and get a velocity of 50.6 fps no matter what the original pressure of the water was.

I then decided to make a practical test, so I turned on a tap and adjusted it so that the stream of water about 6 in. below the tap appeared to be about $\frac{1}{8}$-in. in diameter. I then took an empty Coca-Cola bottle, upon which were embossed the words "6 fluid ounces." Holding the bottle so that the stream flowed into the bottle, I found that it took 10 seconds to fill the bottle to the point where Coca-Cola bottles are usually filled. This was equivalent to 405 gpd. Also, the diameter of the stream was only guessed at, but it was probably a little more than $\frac{1}{8}$ of an inch.

After completing this practical test, I worked back and discovered that the 2,800 gpd had probably been arrived at by assuming a leak that would throw a stream of water of $\frac{1}{8}$-in. diameter from a sharp-edged orifice acting under a head of approximately 20 psi. The pressure in the main outside our building is about 75 psi.

From the above evidence I philosophized that when a kitchen or bathroom tap is opened sufficiently to throw a $\frac{1}{8}$-in. stream of water only, the effect of the pressure in the main is of very little importance, as the water at the orifice of the tap is for all practical purposes reduced to almost zero pressure. Then, assuming that the diameter of the stream were measured one foot below the orifice of the tap, and taking the formula $V = 8.03\ H^{\frac{1}{2}}$ and assuming that H equals 1 ft, the discharge would be about 440 gpd.

In short, my opinion is that with a leak in a faucet, resulting in the discharge of a $\frac{1}{8}$-in. stream of water, the discharge in 24 hours would be more like 400 or 500 gal than 2,800 gal. If the stream were coming from a water main through an orifice in the water main, and the pressure on the water were about 20 psi, and there were no back pressure against this, one might get a discharge in the order of 2,800 gpd. I wonder if you would mind checking this matter with Willing Water for me, as I feel that his statement was a

(*Continued on page 54 P&R*)

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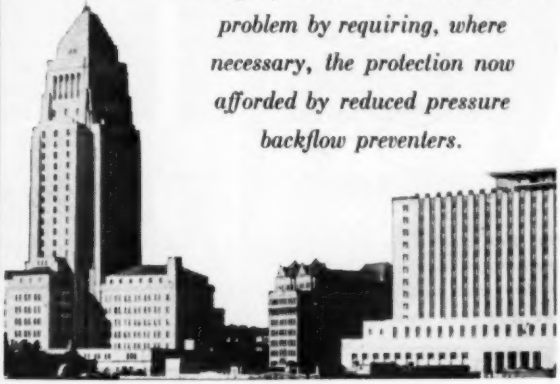

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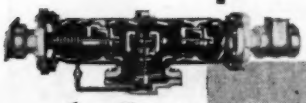

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Correspondence

(Continued from page 52 P&R)

bit of an exaggeration. In my opinion, no exaggeration is required in telling the public of the tremendous job that the water works industry is performing every day.

R. BOWERING

Director, Div. Public Health Eng.
Dept. of Health & Welfare
Victoria, B.C.; Jan. 26, 1954

But that was only at first! After he calmed down a bit, Willie found a slide rule, too, and figured out that 2,800 gpd is the loss that would take place through a ⅛-in. orifice, fully contracted at 60 psi pressure. Of course, that's strictly theoretical, but since the determination of a practical figure to fit every situation would involve more Coke bottles than he could manage, Willie has changed his tune to dodge the direct issue. Thus in the first run of The Story of Water Supply, *the waste figures will be the same, but "stream" will be called "leak" to get back to the orifice idea, and the numbers will be modified by "up to." For giving Willie the willies on his loose usage, however, friend Bowering has been notified that he will receive the Order of the High Watermark posthumorously.*—ED.

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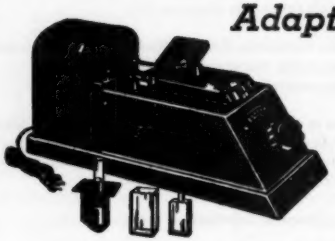

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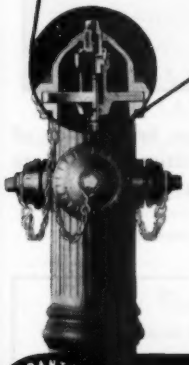

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Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

ANNUAL REPORTS

Community: **Little Rock, Ark.**
Reporting organization: Municipal Water Works
Year ending: Dec. 31, '52
Population served: 173,953
Customers: resid.: 25,378; coml.: 3,767; indus.: 70; other: 448; total: 29,663
Source of supply: L. Winona
Type of treatment: coagulation, chlorination, filtration
Water produced (mil gal): 4,716
Water sold (mil gal): 3,932
Water unaccounted for (%): 9.05
Consumption (mgd): max.: 26; avg 17 (108 gpcd)
Metered services (%): 100
Mains (mi): distr. and trans.: 366
Valves: 3,412
Hydrants: 1,488
Distr. storage (mil gal): 10.5 (clear well)
Revenue ($): water: 1,201,210; other: 55,096; total: 1,256,306
Expense ($): op. and maint.: 416,153; depn.: 82,843; total: 498,996
Tax paid (% of revenue): 3.9
Income ($): 757,310
Bond interest ($): 205,416
Bond retirement ($): 130,000
Book value ($): 10,400,220
Debt outstanding ($): 6,181,200
Unit costs ($/mil gal): water: 6.09; pumping: 4.80; purif.: 15.40; distr.: 17.20
Raw water analysis (ppm): turbidity: 15; total hardness: 11.0; total alky.: 7.0; pH: 6.7; color: 34; coliform index: 11.0/100 ml
Rates (¢/100 cu ft): inside city: 6.75 with no min. charge; outside city: 6.75-23.5 with min. charge of 94¢/mo.

Community: **Muscatine, Iowa**
Reporting organization: Board of Water and Light Trustees
Year ending: Dec. 31, '52
Customers: 5,855
Source of supply: wells
Type of treatment: chlorination
Water produced (mil gal): 1,016
Consumption (mgd): avg: 2.78
Metered services (%): 89
Mains (mi): distr. and trans.: 88.5
Hydrants: 621
Revenue ($): water: 118,138; other: 8,124; total: 126,262
Expense ($): op. and maint.: 81,578; depn.: 19,588; total: 101,165
Free service (mil gal): 17.5
Tax paid (% of revenue): none
Income ($): 25,097
Bond interest ($): none
Bond retirement ($): none

(*Continued on page 64*)

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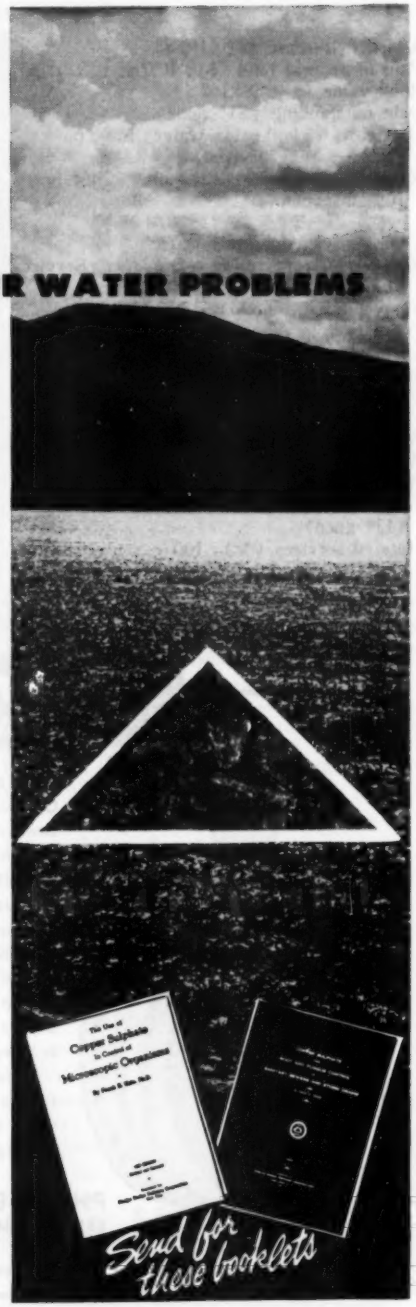

(Continued from page 62)

Added to reserve ($): 19,588
Paid to general fund ($): 10,095
Book value ($): 584,162
Debt outstanding ($): none
Unit costs ($/mil gal): water: 1.38; power: 11.23; distr.: 39.64
Rates (¢/100 cu ft): 5–25; min. bill 46¢/mo.; 10% discount.

Community: **Wyandotte, Mich.**
Reporting organization: Municipal Service Com.
Year ending: Sep. 30, '52
Population served: 38,000
Customers: 10,292
Source of supply: Detroit R.
Type of treatment: coagulation, sedimentation, filtration, chlorination
Water produced (mil gal): 1,936
Water sold (mil gal): 1,431
Water unaccounted for (%): 19
Consumption (mgd): max.: 8.1; avg: 1.44 (139 gpcd)
Metered services (%): 100
Mains (mi): distr. and trans.: 94.97
Valves: 1,000
Hydrants: 756
Distr. storage (mil gal): 1.4 (ground); 0.5 (elevated)
Revenue ($): water: 227,540; other: 9,402; total: 236,942
Expense ($): op. and maint.: 149,667; depn.: 51,051; total: 200,718
Income ($): 36,224
Bond interest ($): 3,064
Added to reserve ($): 51,051
Book value ($): 1,817,448
Debt outstanding ($): 61,000
Unit costs ($/mil gal): pumping: 14.98; purif.: 28.19; distr.: 32.86.

Community: **Elmira, N.Y.**
Reporting organization: Water Board
Year ending: Dec. 31, '52
Population served: 70,000
Customers: 16,266
Source of supply: Chemung R. (63.9%), Hoffman Creek (36.1%)

(Continued on page 66)

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From coast to coast, hundreds of LimiTorque Controls are in service in water works and sewage disposal plants for automatic or push-button operation of valves up to 120 inch diameter. Why is acceptance so widespread? Because LimiTorque Operators are designed to provide dependable, safe and sure valve actuation at all times.

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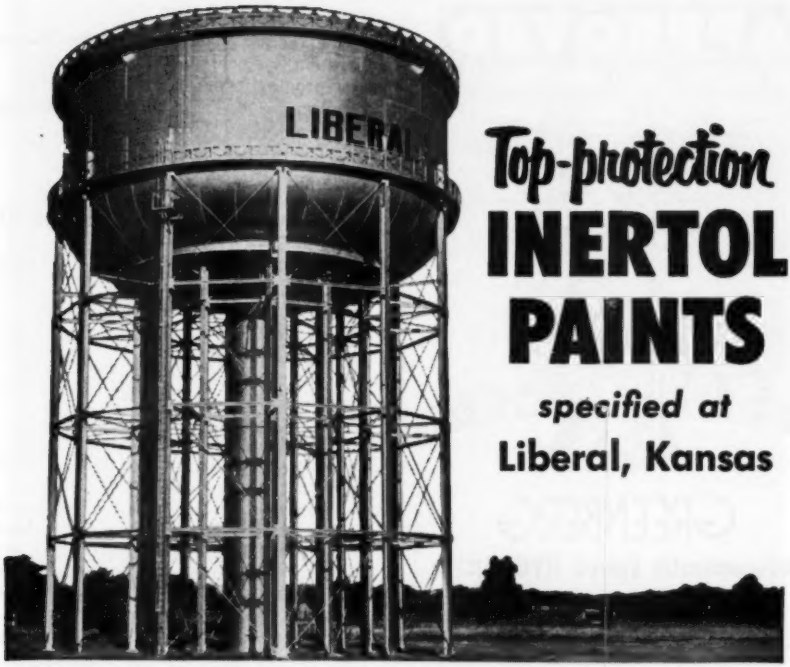

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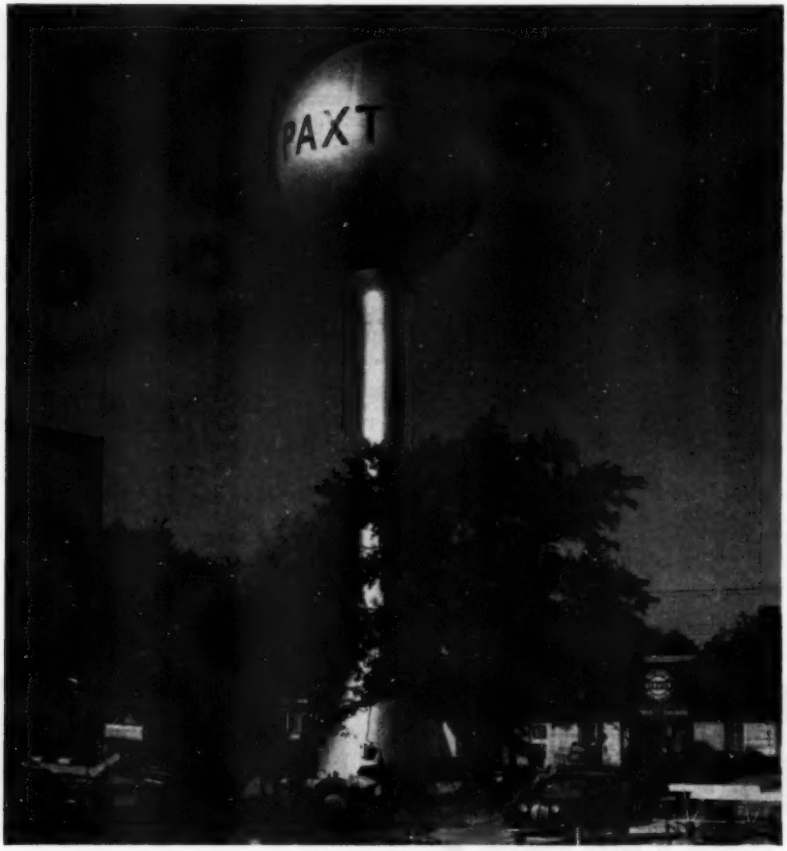
(*Continued from page 64*)

Type of treatment: coagulation, chlorination, filtration, ammoniation, aeration
Water produced (mil gal): 2,584
Consumption (mgd): avg: 7.06 (100 gpcd)
Metered services (%): 100
Mains (mi): distr. and trans.: 179
Hydrants: 898
Distr. storage (mil gal): 6.5
Revenue ($): water: 479,483; other: 8,057; total: 487,540
Expense ($): op. and maint.: 285,934; depn.: 61,157; total: 347,091
Tax paid (% of revenue): 4.1
Income ($): 140,449
Bond interest ($): none
Bond retirement ($): none
Added to reserve ($): 57,557
Book value ($): 3,941,888
Debt outstanding ($): none
Unit costs ($/mil gal): pumping: 25.20; purif.: 23.50; distr.: 26.00
Raw water analysis (ppm): Chemung R. supply: color: 8.0; turbidity: 5.0; hardness: 174; alky.: 94.0; iron: 0.20; pH: 7.9; Hoffman Creek supply: color: 40.0; turbidity: 50.0; hardness: 58; alky.: 26.0; iron: 1.75; pH: 7.1; temp. (°F): 36–76
Rates (¢/100 cu ft): inside city: 8–35, with min. bill of $2.80/quarter; outside city: 9–42, with min. bill of $3.36/quarter; bills rendered monthly where consumption exceeds 60,000 cu ft/quarter; 10% discount.

Community: **Halifax, N.S.**
Reporting organization: Public Service Com.
Year ending: Dec. 31, '52
Population served: 103,962
Customers: 14,773
Source of supply: lakes
Type of treatment: corrosion control (lime), chlorination
Water produced (mil gal *): 3,465
Consumption (mgd *): avg: 9.48 (94 gpcd)
Metered services (%): 100
Mains (mi): distr. and trans.: 129
Valves: 1,771
Hydrants: 871
Distr. storage (mil gal *): 3.64
Revenue ($): water: 902,263; other: 33,568; total: 935,831
Expense ($): op. and maint.: 434,740; depn.: 80,000; total: 514,740
Tax paid (% of revenue): 1.7
Income ($): 421,091
Bond interest ($): 225,000
Bond retirement ($): included above

(*Continued on page 68*)



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(Continued from page 66)

Added to reserve ($) : 60,000
Paid to general fund ($) : 100,000
Book value ($) : 8,953,563
Debt outstanding ($) : 5,000,000
Unit costs ($/mil gal *) : treatment : 10.40; pumping : 12.50

Community : **Sheffield, England**
Reporting organization : City Council Water Committee
Year ending : Mar. 31, '52
Population served : 543,900 retail; 209,000 wholesale
Customers : 193,944
Source of supply : surface water
Type of treatment : filtration, chlorination
Water produced (mil gal *) : 17,748
Metered services (%) : 3
Consumption (mgd *) : avg : 48.36 (65 gpcd *)
Mains (mi) : distr. and trans. : 977
Hydrants : 11,082
Revenue (£) : water : 802,643; other : 11,460; total : 814,103
Expense (£) : op. and maint. : 509,757; other : 65,992; total : 575,749
Income (£) : 238,354
Bond interest (£) : 117,966
Bond retirement (£) : 114,810
Added to reserve (£) : 302
Paid to general fund (£) : none
Debt outstanding (£) : 4,190,612

* Imperial gallons.

Community : **Bombay, India**
Reporting organization : Hydraulic Eng. Dept.
Year : '51–'52
Population served : 2,842,116
Customers : resid. : 53,410; coml. : 2,816; indus. : 1,176; total : 57,402
Source of supply : lakes
Type of treatment : filtration, chlorination, chloramination
Water produced (mil gal *) : 43,926
Water sold (mil gal *) : 37,842
Water unaccounted for (%) : 13.85
Consumption (mgd *) : max. : 132; avg : 120 (43 gpcd *)

* Imperial gallons.

(Continued on page 70)

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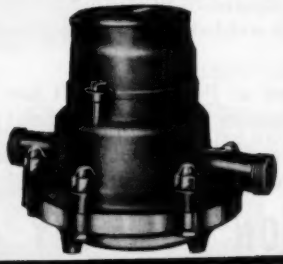

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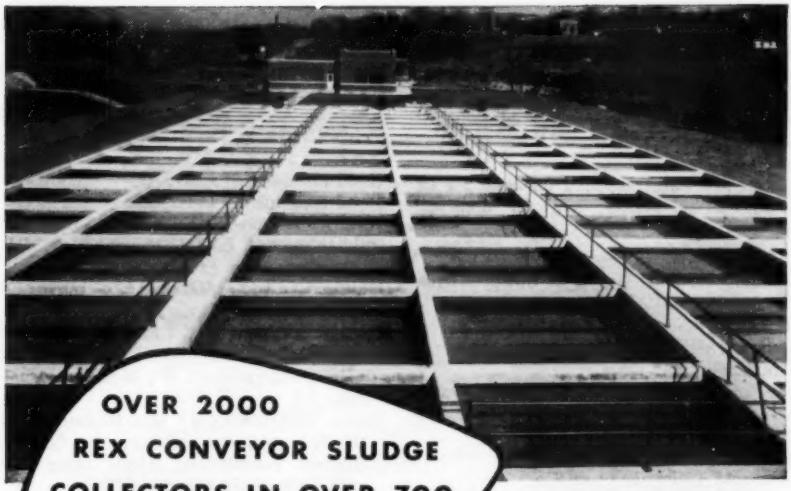

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(*Continued from page 68*)

Metered services (%): 10.2
Distr. storage (mil gal *): 50.5 (gravity); 0.81 (pumped)
Revenue (rupees): 16,474,345
Unit costs (rupees/mil gal *): chemicals: 6.52
Other items: water supplied for only 5–7 hr during 24-hr period; avg for domestic purposes was 25.9 gpcd.*

Community: **Rand, Union of South Africa**
Reporting organization: Water Board
Year ending: Mar. 31, '52
Population served: 1,768,000
No. of employees: 1,807
Source of supply: surface and ground water
Type of treatment: softening, filtration, chlorination
Water produced (mil gal *): 37,455
Water sold (mil gal *): 36,015
Water unaccounted for (%): 2.79
Consumption (mgd *): max.: 127; avg: 98.6 (55 gpcd *)
Metered services (%): 100
Distr. storage (mil gal *): 114.4
Revenue (£): water: 1,406,900; other: 31,-670; total: 1,438,570
Expense (£): op. and maint.: 664,386; depn.: 50,022; total: 714,408
Income (£): 724,162
Bond interest (£): 239,282
Bond retirement (£): 242,533
Added to reserve (£): 125,000
Paid to general fund (£): none
Debt outstanding (£): 6,570,464
Unit cost (d.†/1,000 gal *): purif.: 96; pumping: 1.74
Water analysis (ppm): alky.: 55; Na + P: 19; hardness: 91; Ca: 25; Mg: 6; chlorides: 15; sulfates: 47; bicarbonates: 67; pH: 8.5
Rates: 7d.†/1,000 gal * plus prorated charge to all constituent customers for bond and interest redemption, which brings total rate up to 9.69d.†/1,000 gal *
Other items: water supplied in bulk to 12 municipalities, plus many large industrial users.

* Imperial gallons.

* Imperial gallons.
† Pence.

(*Continued on page 72*)

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PIONEERS IN METERS AND CONTROLS

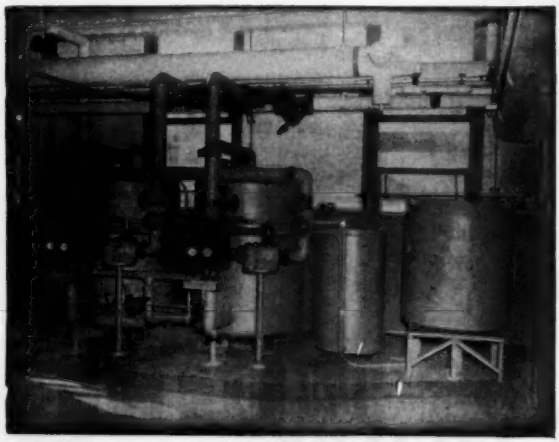
(*Continued from page 70*)

BACTERIOLOGY

A New Solid Medium for Determining Coliform Bacteria by Direct Inoculation. R. FERRAMOLA & R. HUERIN. Rev. Obras San. de la Nacion (Argentina), 16:359 ('52). Determination of coliform bacteria by inoculating volumes of water sample directly in solid culture media has not been widely practiced in spite of obvious advantages of method. This is due principally to lack of culture medium which differentiates with certainty those bacteria which ferment lactose by producing acid, from those which do so by producing acid and gas. Medium has been developed by authors in which coliform bacteria are identifiable at end of 48-hr incubation at 37°C. Colonies of *Esch. coli* develop to 0.5 cm in diameter and are flat, dry, deep violet in color over whole surface of colony, and exhibit metallic sheen. *Aer. aerogenes,* on other hand, produces raised, mucoid, confluent colonies somewhat smaller in size and of violet color in center but whitish on periphery. Intermediate coliform types are more difficult to identify, colonial morphology sometimes being similar to *Esch. coli* types. [Descriptions of colonies do not differ markedly from those of colonies developing on Levine's EMB agar.] Medium described has high inhibitory power for non-coliform bacteria; 96% colonies were confirmed as coliform organisms from plates inoculated with polluted waters and 72% were confirmed as typical coliform organisms from less seriously polluted rivers.

A Note on the Absolute Viability in Water of *S. typhi* and the Dysentery Bacilli. J. F. D. SHREWSBURY & G. J. BARSON. Br. Med. J., p. 954 ('52). Expt. was made to determine max. period of survival of dysentery bacilli in water. *S. typhi, Sh. sonnei, Sh. flexneri Y,* and *Sh. shigae,* at concentrations of 10^9/ml in tap water, distilled water, and normal saline solution, were kept in diffuse daylight at room temperature under aerobic conditions and were tested for viability at regular intervals. Results given in table show that *Sh. shigae* perished most

(*Continued on page 74*)



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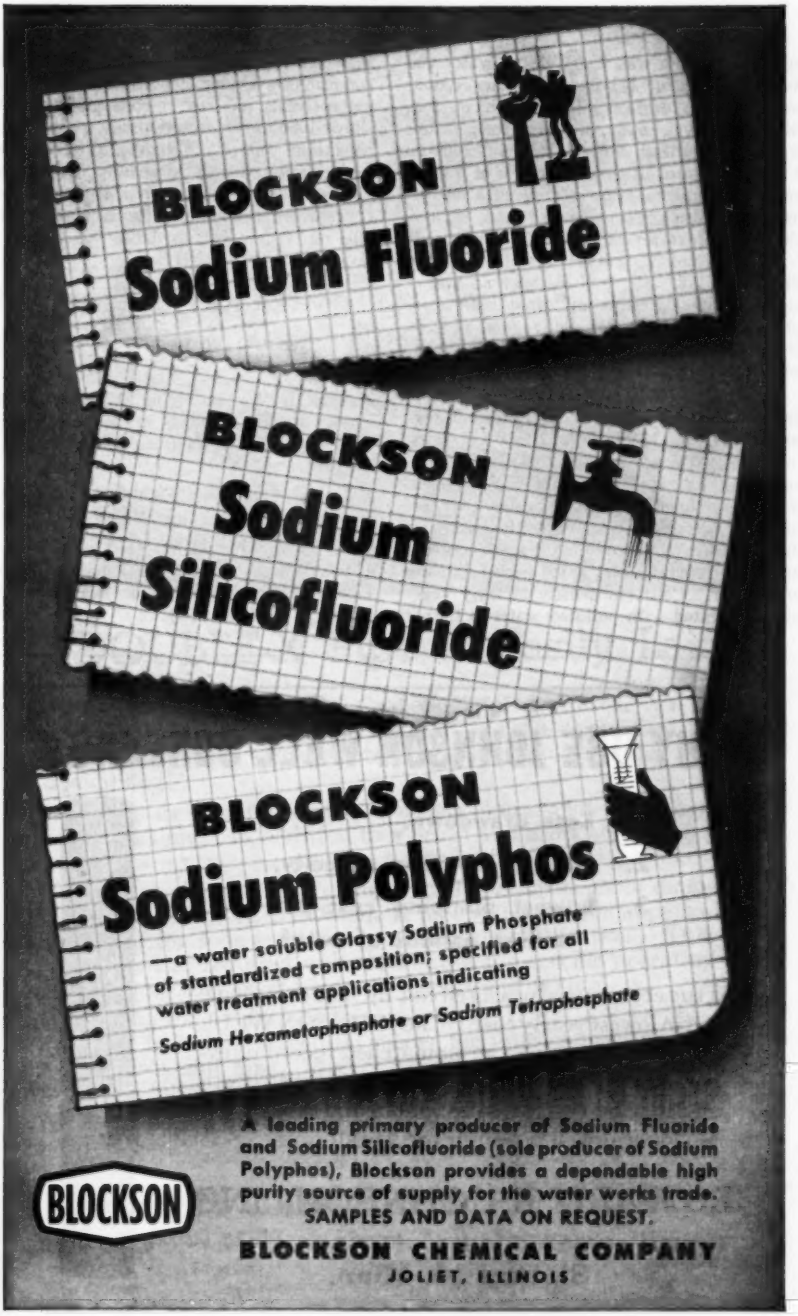
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(Continued from page 72)

quickly; *S. typhi* was viable in tap water and distilled water for 211 days. As suspensions evaporated to dryness after 236 days, furthere expt. was made in which suspensions of each organism were made in 200 ml of distilled water at concentrations of 5×10^8 and 1×10^8/ml. At lower concentration, no viable organisms were detected after 59, 107, 238, and 7 days for *S. typhi, Sh. sonnei, Sh. flexneri Y,* and *Sh. shigae,* respectively, and after 474, 197, 391, and 7 days at higher concentration. Results indicated that absolute viability of *S. typhi, Sh. sonnei,* and *Sh. flexneri Y* in chemically inert medium depends upon density of cell population.—*WPA*

Bacteriological Study of Irrigated Vegetables. N. N. NORMAN & P. W. KABLER. Sew. Ind. Wastes, **25**:605 ('53). Coliform content of irrigated soils studied reflects, in general, coliform density of water they receive. Vegetables irrigated with waters of high coliform count exhibit higher coliform flora than vegetables irrigated with relatively pure water. Coliform density of leafy vegetables irrigated with polluted water is higher than smooth vegetables grown under similar conditions. Under condition of this study, enterococcus indexes of soils and vegetables showed no direct relationship to indexes of irrigation waters. *Salmonella* were present in irrigation waters in readily demonstrable numbers, were present in soils in only low concentration, and were insufficiently numerous on vegetables to be demonstrated by procedures used.—*PHEA*

OTHER ARTICLES NOTED

Recent articles of interest, not abstracted, are listed below.

Radioactive Gages Signal Water Content of Snow Packs as Aid in Runoff Control. ANON. Eng. News-Rec., **151**:26:24 (Dec. 24, '53).

Palisades Dam—An Earthfill With Special Features. ANON. Eng. News-Rec., **151**:27:28 (Dec. 31, '53).

How Waste Water Reclamation Affects Ground Water Pollution. ANON. Pub. Wks., p. 59 (Jan. '54).

WHY USE JOHNSON WELL SCREENS?

1. **Less drawdown.**
2. **Greater specific capacity.**
3. **Lowest pumping cost per million gallons of water.**

True economy is measured not by first cost alone, but in lowest yearly cost. The JOHNSON WELL SCREEN combines an unmatched record of experience and dependability with greatest strength and durability. It is the finest and most truly economical well screen in the world.

EDWARD E. JOHNSON, INC.

~ well screen specialists since 1904 ~

St. Paul 14, Minn.

DOUBLE-X Pipe Is Easily Laid

Manufactured by the Mono-Cast centrifugal process, AMERICAN Double-X pipe is equipped with the standardized mechanical joint. It is furnished complete with gaskets, cast iron glands, and cast iron bolts for assembling.

The joints are so simple and rugged that common labor can make them up in record time. In addition to a brush and a bucket of soapy water, only one tool—a ratchet wrench—is required.

Manufactured centrifugally under rigid specifications in diameters 2″ through 48″, AMERICAN Double-X pipe will stand the impact of heavy loads on shifting soils and gives complete job satisfaction. This pipe is manufactured to required wall thicknesses for specific operating conditions. You get the exact pipe your conditions require.

A complete line of fittings for use with AMERICAN Double-X pipe is available including transition pieces for inter-connecting with other types of joints and pipe. Branch stocks of both pipe and fittings are strategically located for your convenience.

Write for AMERICAN Double-X pipe booklet. A free copy will be sent on request.

AMERICAN CAST IRON PIPE COMPANY

Birmingham 2, Alabama

Dallas Houston El Paso Pittsburgh Kansas City
Chicago Minneapolis New York City Cleveland
Los Angeles San Francisco Seattle Denver

(Continued from page 44 P&R)

The Pitometer Associates, Inc., is the new name of the firm of distribution system specialists previously known as the Pitometer Co.

A thing of beauty is what Willa Frederic calls water in the title of an article she wrote for *Town and Country* last August. And the same goes for her as far as we're concerned—particularly if she's the girl bathing under a waterfall in the picture accompanying the article. "Water," Willa enthuses, "is a joy for its cleansing and psychologic effect." Then she proceeds:

The therapeutic value of water is no less beautifying than its cleansing properties. Very hot and very cold baths are stimulants, adding a glow to the skin [unfortunately the picture wasn't in color] and a sparkle to the eye. Warm baths, summer or winter, relax tensions, lessen fatigue and irritability, smooth away tautness of face and body.

Moving waters, playing against the skin, have a decided effect on the central nervous system. Fifteen or twenty minutes in a tub of warm water with open faucet and drain, letting the water flow continuously [poor conservation, but good business] tones the whole body. This simple operation simulates the mechanically agitated waters of the whirlpool baths used in hospitals and prescribed for back and muscular pains, incorrect posture, insomnia, nervous tension, and even psychoses.

And when you tear yourself away from your tub, you might give your customers a clue to the kind of commodity you're practically giving away. A joy forever!

(Continued on page 78 P&R)

BELCO

An organization of engineers engaged in the design, development and fabrication of equipment for "Removal of Water Impurities". Belco technicians, chemists and electronic control specialists have designed and furnished water treating installations ranking from the smallest to the largest in the world. For a discussion or analysis of your problems call a Belco man.

Belco
INDUSTRIAL EQUIPMENT DIVISION, INC.
PATERSON 3, NEW JERSEY
Regional offices in many cities

MUNICIPAL SUPPLIES

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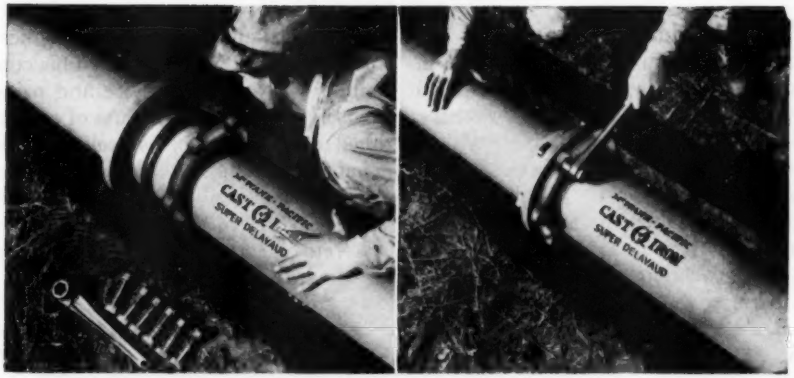


EASY TO LAY

WITH UNTRAINED LABOR

SAVES TIME REDUCES COSTS

McWane-Pacific Boltite mechanical joint pipe and fittings lay faster and reduce pipe line construction costs because the joints can be made by untrained workmen using only a ratchet wrench. Boltite is a better joint for either water or gas. Bottle-tight, leak-proof, yet flexible to allow settlement, or expansion and contraction of the pipe line.

All joint parts, glands, gaskets and bolts are interchangeable with pipe, fittings, valves and hydrants made by other manufacturers. For complete information, wire or write McWANE CAST IRON PIPE COMPANY, Birmingham, Alabama, or PACIFIC STATES CAST IRON PIPE COMPANY, Provo, Utah. (Sales offices in principal cities.)

McWANE PACIFIC Q PIPE *Lasts for Centuries*

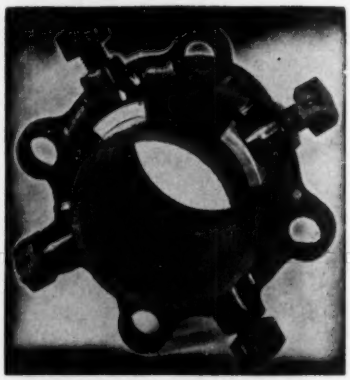
(Continued from page 76 P&R)

The fluoridation report of the United Kingdom Mission to the U.S. and Canada (*see* September 1953 Reading Meter, p. 52 P&R) was the subject of parliamentary inquiry last December, when the Minister of Health was asked whether he planned to accept the recommendations of the report, which advised that studies be made in selected communities before general adoption of fluoridation of water supplies. The upshot of the exchange is that the Ministry accepted the report of its fact-finding mission and is preparing to implement it.

Francis B. McDowell Jr. has retired as chief engineer and manager of the Charleston, S.C., water works, being succeeded by John R. Bettis, formerly assistant manager and engineer. Mr. McDowell, who has given his community 35 years of service and prides himself on his pioneering use of cement-lined cast-iron pipe, as well as many local construction achievements, won his section's Fuller Award in 1949. When last heard from, he was enjoying his retirement—by showing up at his desk as usual every day.

Ralph A. Hagberg, formerly Cleveland office manager for Industrial Chemical Sales Div., West Virginia Pulp & Paper Co., has joined the S. S. Skelton Co. of Cleveland and Akron. The firm presently distributes chemicals for a variety of industries, and is planning to introduce a line of water treatment chemicals soon.

(Continued on page 80 P&R)



ANCHORED CLAMP for MECHANICAL JOINTS

Also CI-60 charcoal cast iron bolts for mechanical joints; ball-joint Leak Clamps and Gasket Sealer Compound.

Write for information

H. Y. CARSON COMPANY
1221 Pinson St. Birmingham, Ala.

TRANSITE FILTER BOTTOMS LAST THE LIFE OF THE PLANT

Consider
THESE ADVANTAGES:

- ★ Lifetime Materials
- ★ Cut Filtration Costs
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NOW INSTALLED IN SEVERAL OF NATION'S FINEST FILTER PLANTS
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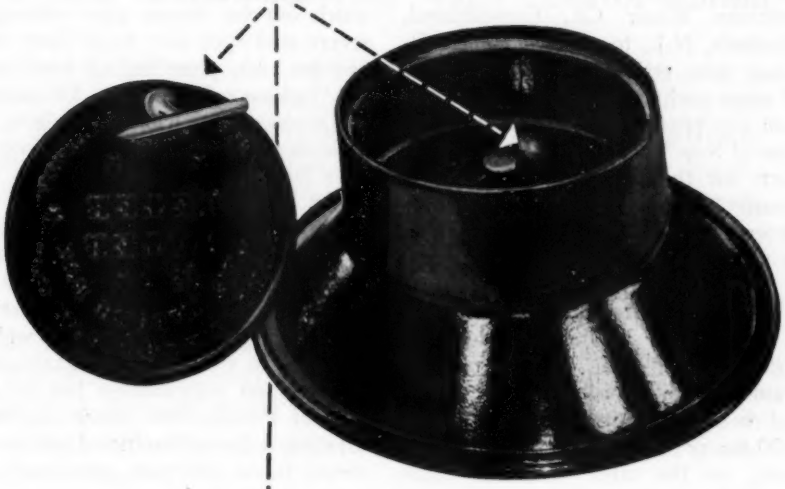
WABASH DOUBLE-LID COVERS



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The new No. 50 Ford Catalog contains full information. FREE. Send today.

The Wabash Cover was designed to provide the utmost in frost protection for pit water meters. Two lids, with a 4" dead air space between, add extra insulation. Notice also, the extra depth and the sloping skirt that help hold heat loss to a minimum.

Top lid is inset and locked with the patented Ford Lifter Worm Lock. There is no finer meter setting protection.

FOR BETTER WATER SERVICES FORD

Manufactured by THE FORD METER BOX COMPANY, INC.

Wabash, Indiana

(Continued from page 78 P&R)

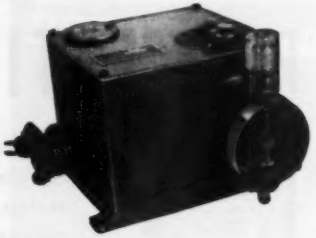
James Girand has been appointed chief operations executive of the Elizabethtown Water Co., Consolidated, Elizabeth, N.J., to succeed Robert R. Stone, who retired last August after 22 years as chief engineer. Girand has been vice-president in charge of operations of New York State Water Service Corp. for the past four years. Previously he had been city engineer of Phoenix, Ariz., and superintendent of its water department.

Out of his element was Clarence L. Drinkwater at the last picnic of Milwaukee milkmen. At any rate, he drank beer and whiskey like water and had to be haled into court and soaked $100 for drunken driving. In his element, on the other hand, is Little Rock's Les Jackson, water works manager, who for a second time did a masterful job of warning his customers to watch out for frozen pipes during a severe cold spell only to go home and find his own plumbing all iced up—Les Jackson's little rock. Of course, if Drinkwater's drinks had been in Jackson's plumbing, they both would have been better off. But then, we prefer ours on the rocks.

Joseph T. Ryerson & Son, Inc., has been appointed a distributor of plastic pipe and fittings made by Carlon Products Corp. Although most widely known as a steel service organization, the Ryerson organization has an Industrial Plastics Div. which has been handling a line of laminated plastics in sheets, tubes, and rods, principally for use as bearings.

(Continued on page 84 P&R)

PRECISION
Chemical Pumps for:



Chlorinating swimming pools, drinking water, wastes
Fluoridation of municipal water supplies
Corrosion and scale control, phosphate injection
Chemical waste treatment—Automatic sampling

Accurate, dependable, positive displacement, diaphragm type pumps. Constant rate or meter-paced for automatically variable output.

PRECISION MACHINE COMPANY
8 Walnut Street **Somerville, Mass.**

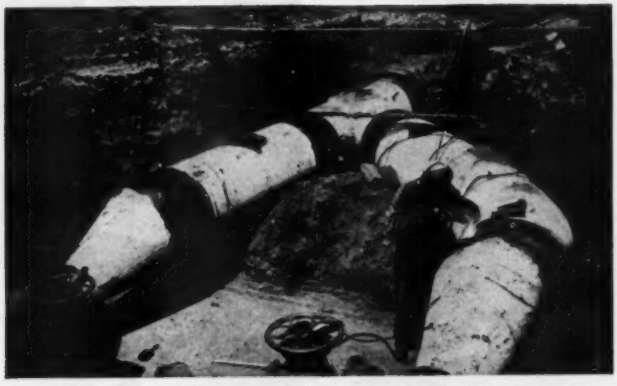
STEEL PIPE solves headroom problem as Newark modernizes vital water control station

In Newark, the Bloomfield Avenue Tower is the vital terminal for five of the City's six main feeder lines. Modernization at the Tower called for critical selection of new pipe for maximum strength and flow in minimum headroom.

The problem was solved with 1650 ft of 48-in., 450 ft of 36-in. and 30 ft of 60-in. Alco Electric Welded Steel Pipe. Through it will surge more than 85 million gallons of water per day.

Furnished in diameters from 20 to 120 in. and lengths to 40 ft, Alco Electric Welded Steel Pipe is specified the country over for its engineered strength, efficiency, economy and long life.

Use it in your installation, be it large or small, special or standard. Your Alco Products sales representative will be glad to give you complete technical data—plus expert help on your own special problems.



CITY OF NEWARK uses strong, efficient Alco Electric Welded Steel Pipe in 36, 48 and 60-in. diameters and special sections (shown above) at vital Bloomfield Tower control station.

Remember these Key features of Alco Steel Pipe:

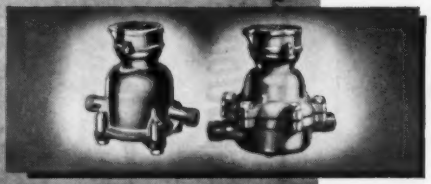
STRONG • EFFICIENT • ECONOMICAL
DURABLE

ALCO
PRODUCTS

AMERICAN LOCOMOTIVE COMPANY
DUNKIRK, N. Y.

Sales Offices: New York, Chicago, Dunkirk, Los Angeles, Kansas City, Houston, Tulsa, Beaumont.

WATER
is vital...



BADGER meters conserve it!

More than 25 million acres of crops must be irrigated to provide America's food supply. The Badger water meters used in thousands of communities throughout the nation help save water for this vital need . . . measure water accurately for homes and industry . . . provide a precise check on water usage and waste. With their outstanding record of performance, Badger meters have won the praise of waterworks men everywhere . . . are known as the meters that save water, work, money!

BADGER WATER METERS

BADGER METER MFG. CO., Milwaukee 45, Wisconsin

"Measuring the water of the world"

(*Continued from page 80 P&R*)

Arch friend and staunch supporter these days is water, and it's all done with hydraulics. Actually, this triumph for the arch—full fallen or only slightly slipping—was accomplished by a sore-footed friend in the dental profession, who placed a rubber sack full of water on top of a sponge rubber pad in his shoe and created the "Fluid-Arch Support." In addition to moving with the foot as it supports the arch, and, thereby, cushioning the blow of walking, F-AS is reported to "improve balance, massage the foot, increase circulation, etc." What's in that modest or secretive "etc.," of course, no one can be sure, but pedal insulation must be in mind; and emergency water supply for those lost in the desert, atom-bombed, or similarly stricken; and, properly superchlorinated, ever-ready athlete's foot prevention; and, at long last, dependable antihotfootment. However many more applications there may be, we can certainly add another to water's powers—water, now, for arch or parch; water for feet or heat; water for ease or disease. So who cares if arch friend is stench supporter too?

Grooved ends are now being provided on one model of the standard Nordstrom semi-steel plug valve in order to facilitate connection to steel pipe with grooved end couplings. The valve is produced by Rockwell Mfg. Co. in sizes from 2 to 4 in., has a pressure rating for water, oil, or gas of 175 psi and is operated by wrench.

(*Continued on page 86 P&R*)

AA QUALITY
THE AMERICAN AGRICULTURAL CHEMICAL COMPANY

For Public Water Fluoridation

Sodium Silicofluoride—98%
(Dense Powder)

Sodium Fluoride—98%
(Dense Powder or Granular)

Meets AWWA specifications

White or tinted blue
Minimum of dust in handling
Minimum of storage space
Available in bags and drums

The AMERICAN AGRICULTURAL CHEMICAL Co.
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WATER COMMISSIONERS
OF THE
TOWN OF WATERFORD, N.Y.

September 15, 1952

Simplex Valve and Meter Co.,
68th & Upland Sts.
Philadelphia 42, Pa.

Dear Sirs:

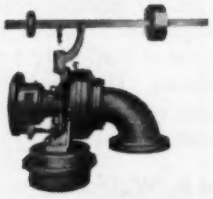
Please send us two (2) rubber diaphragms for Simplex rate controller #6 111325 B.

Might be of interest to know that this is second replacement of diaphragm since 1914.

Respectfully yours,
R. G. Jaffley

Water Commissioners,
Waterford, N. Y.
Supt.

Another proof that Simplex is reliable in the long run!



Simplex Type S
Rate of Flow
Controller
(Supersedes Type B Controller Referred to in Letter)

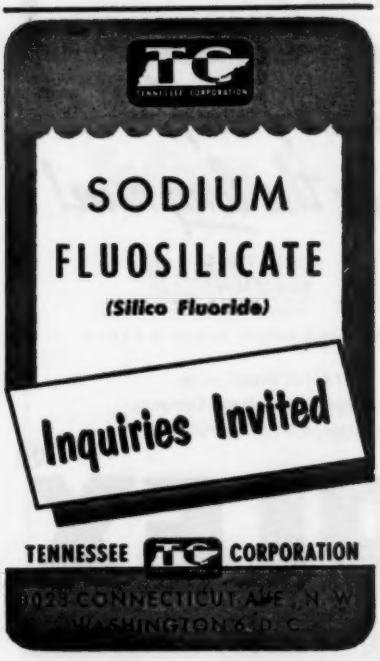
For full details, write:
Simplex Valve & Meter Company,
6784 Upland St., Philadelphia 42, Pa.

SIMPLEX®
VALVE AND METER COMPANY

(*Continued from page 84 P&R*)

John J. McCarthy, who at 61 had been director of the Racine, Wis., laboratories for 30 years, died unexpectedly while undergoing an operation at Rochester, Minn., on January 15th. He had only recently been nominated for his section's Fuller Award, which was to have been presented at the Seattle Conference next May.

After an early career in medical research and pathology, interrupted by a period of service in the Sanitary Corps during World War I, he came to Racine as director of the health department laboratory in 1923, taking over supervision of the water department's laboratory as well four years later. He was one of the founders of the West Shore Water Producers Assn. and had served as Wisconsin Section chairman in AWWA.



D. Birney Stokes, who retired in 1952 as vice-president in charge of sales for U.S. Pipe & Foundry Co., died at his home in Edgewater Park, N.J., on Jan. 17th. He had been with the foundry from 1910 until his retirement, and had been a member of ASA Sectional Committee A21, which last year completed its work on a number of new cast-iron pipe specifications.

H. A. Van Norman, one of the architects of the Los Angeles water system and long its chief engineer and general manager, died on January 16, at the age of 78.

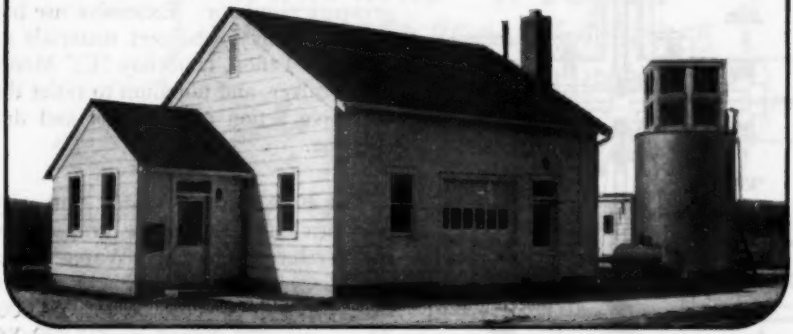
Wainwright, Ramsey & Lancaster, municipal finance consultants of New York, have changed their firm name to Wainwright & Ramsey Inc.

Paul G. Agnew, former ASA secretary, died at his home in New York on January 8th, at the age of 72. A pioneer in the standardization movement, he left a post as physicist with the Bureau of Standards to become secretary of the newly formed American Standards Assn. in 1919. In addition to guiding the successful growth of that organization over the years, he helped to organize the International Organization for Standardization (ISO), and its predecessor, the International Federation of National Standardization Associations. He retired from ASA in 1947, but remained on the staff as a consultant until 1952.

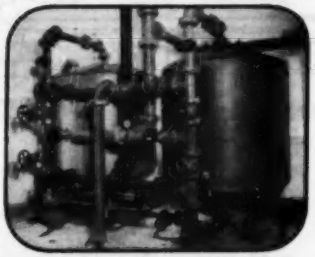
Fred A. Waterous, president of the Waterous Co., St. Paul, Minn., has been elected to the board of directors of the National Assn. of Manufacturers. He is currently serving as president of the Fire Apparatus Manufacturers Assn.

(*Continued on page 88 P&R*)

How Martinsville gets iron-free, soft water



Martinsville, Illinois Municipal Water Plant



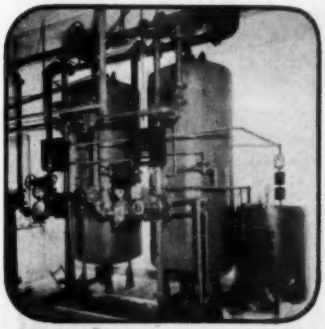
Compact Permutit pressure filters have a 150 gpm capacity...remove iron oxidized in coke-tray aerator, reduce turbidity.

Martinsville's untreated well water was a wasteful nuisance!

Its 269 ppm of total hardness ruinously scaled pipes . . . annoyed citizens by wasting soap, leaving rings around bathtubs, sticky curd on dishes, laundry. Iron of 2 ppm gave it an unpleasant metallic taste, stained laundry.

These troubles were ended when Martinsville installed the Permutit equipment shown. On a recent check, we asked for the operator's opinion of our equipment.

Mr. O. Wiser—who is in charge of this plant—reports: "The Permutit equipment is very good . . . has worked very well with very little maintenance."



Permutit softeners remove hardness, further reduce iron to 0.02 ppm! Automatic regeneration saves time . . . provides constant supply of softened water.

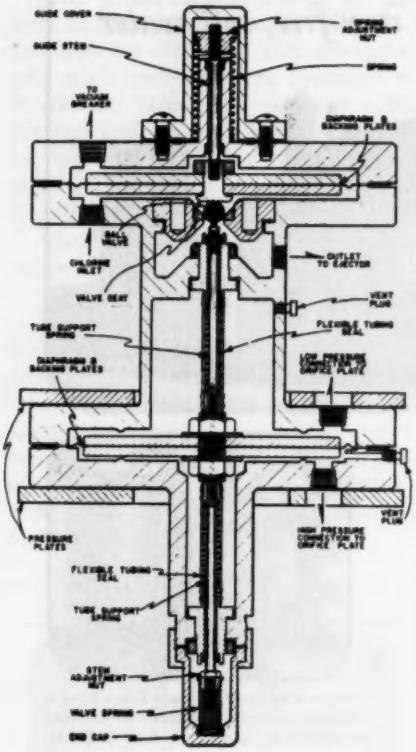
Free Technical Bulletins

Write today for full information on any water conditioning process or problem. THE PERMUTIT COMPANY, Dept. JA-3 330 West 42nd Street, New York 36, N. Y.

Water Conditioning Headquarters For Over 40 Years

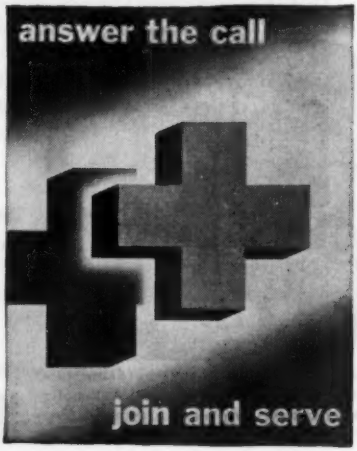
PERMUTIT®

(Continued from page 86 P&R)



High capacity chlorinators have been announced by Fischer & Porter Co. in six models offering a chlorine feed range of from 100 to 6,000 lb per day. Known as the 1052 Ratochlor, the units operate on an all-vacuum, solution-feed principle through a direct-reading flowmeter. Either manual or automatic proportioning control is available, the latter at an announced cost of less than $2,000. The proportioning model makes use of the pressure differential at an orifice in the main line to actuate a diaphragm system (shown), which in turn changes the loading of a pressure regulator to alter the flow of chlorine. Safety features include shutoff of chlorine upon loss of vacuum, physical breakage, or fall of temperature to a level at which liquid chlorine might appear in the pressure regulator. Extensive use has been made of such inert materials as Uscolite, Teflon, Hastelloy "C," Monel metal, silver, and tantalum to resist the corrosive action of both wet and dry chlorine.

The Erie County Water Authority has purchased the entire property of the Western New York Water Co., a subsidiary of New York Water Service Corp., at a total cost of $15,054,000. The authority floated a $17,800,000 bond issue to finance the purchase. Employees of the company have been transferred to the authority's payroll without change in salary, and those with a year or more of service have been given civil service status. Hugh S. Dewey, president of the company, has been retained by the authority as general manager, and Harry Huy, superintendent of operations, stays on as executive engineer in charge of operations.



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Bronze Goods for: WATER SERVICE
Gas Service · Oil Service · Fire Protection

CHANGES IN MEMBERSHIP

NEW MEMBERS

Applications received Jan. 1–31, 1954

Abplanalp, Glen H., Prin. Engr., Havens and Emerson, 233 Broadway, New York 7, N.Y. (Jan. '54) *MRPD*

Alling, S. F.; *see* Hungerford & Terry, Inc.

Amack, Russell B., Operator, Long Beach Water Dept., 3610 E. Spring St., Long Beach, Calif. (Jan. '54) *P*

Angle, J. D., Sales Mgr., Pacific Water Works Supply Co., 2900—1st Ave. S., Seattle, Wash. (Jan. '54) *M*

Arnow, Maurice, Lab. Technician, 827 E. Jefferson St., Phoenix, Ariz. (Jan. '54) *P*

Axford, Harry, Production Supt., Servel Inc., Evansville, Ind. (Jan. '54) *M*

Ballantine, Robert W., Adv. Mgr., Neptune Meter Co., 50 W. 50th St., New York 20, N.Y. (Jan. '54)

Barry, Louis G., Waterford Township Clerk, 4995 W. Huron, Pontiac, Mich. (Jan. '54) *MRD*

Bellflower Water Co., Robert R. Wentworth, Supt., 9701 E. Belmont Ave., Bellflower, Calif. (Corp. M. Jan. '54) *MRPD*

Benedetti, A. J., Civ. Engr., Water Div., Dept. Public Utilities, Tacoma, Wash. (Jan. '54) *MR*

Benjamin, Edwin D., Partner, Thomas & Benjamin, Box 266, Grand Island, Neb. (Jan. '54) *RP*

Bernhardt, Carl J., Regional Director of Public Health Eng., State Dept. of Health, 374 Delaware Ave., Buffalo 2, N.Y. (Jan. '54) *RP*

Blackmon, William P., Salesman, Neptune Meter Co., 254 Spring St., N.W., Atlanta 3, Ga. (Jan. '54)

Brewer, Richard N., Gen. Mgr., Boyd E. Phelps, Inc., 1000 Washington, Michigan City, Ind. (Jan. '54) *RPD*

Busselle, Robert J., Sales Repr., Grinnell Corp., 1374 Clinton St., Buffalo, N.Y. (Jan. '54) *D*

Carls, Harold M., Supt., Water & Sewer Dept., Board of Public Works, Coldwater, Mich. (Jan. '54) *M*

Case, J. W., Jr.; *see* Norwood Corp.

Challacombe, Robert D., Regional Repr., Water Supply Analysts Inc., 418 N. Pine Ave., San Gabriel, Calif. (Jan. '54) *RP*

Chapman, L. O., Pres., L. O. Chapman Co., Inc., Box 3694, Charlotte 3, N.C. (Jan. '54) *PD*

Chew, Kit Lin, Asst. Engr., Public Works Dept., Seremban, Negri Sembilan, Malaya (Jan. '54) *PD*

Clark, David M.; *see* Clark Publishing Co.

Clark Publishing Co., David M. Clark, Exec. Editor, *The Municipal South*, 218 W. Morehead St., Charlotte, N.C. (Assoc. M. Jan. '54)

Coniello, Anthony F., Comptroller, Hackensack Water Co., 4100 Park Ave., Weehawken, N.J. (Jan. '54) *M*

Davidson, Arthur B., Sales Engr., Grinnell Co. Inc., Atlanta, Ga. (Jan. '54)

DeBoer, Obed, City Engr., 204 W. 11th St., Goodland, Kan. (Jan. '54)

deBruin, William E., Civ. Engr., deBruin & King, 2045 Hempstead Tpke., East Meadow, N.Y. (Jan. '54)

Demler, Lester E., Mgr., Chem. Feeder Dept., Wallace & Tiernan Inc., 25 Main St., Belleville 9, N.J. (Jan. '54) *P*

Dubus, Andre J., Supt., Gulf State Utilities Co., Box 892, Lake Charles, La. (Jan. '54) *M*

Emerson, J. Perry, N.Y. State Sales Agent, U.S. Pipe & Foundry Co., 317 State Tower Bldg., 109 S. Warren St., Syracuse, N.Y. (Jan. '54)

Erwin, R. Blake, Cons. Engr., 600 Erie Ave., Niagara Falls, Ont. (Jan. '54)

Eshelman, Joseph W., Jr.; *see* Eshelman, Joseph W., & Co., Inc.

Eshelman, Joseph W., & Co., Inc., Joseph W. Eshelman, Jr., Secy., 1812—28th Ave. S., Birmingham 9, Ala. (Assoc. M. Jan. '54)

Floberg, Joseph W., Assoc. Engr., Eng. Dept., 404 County City Bldg., Seattle 4, Wash. (Jan. '54)

Fog-Tite Meter Seal Co., Grover H. Smith, Sales Mgr., 2839 W. 58th St., Seattle 7, Wash. (Assoc. M. Jan. '54)

Ford, Gus, Supt., Water Dept., 65 Parkview Ave., Daly City, Calif. (Jan. '54) *M*

Foreman, Joseph D., Jr., Salesman, J. B. Clow & Sons, 201 N. Talman Ave., Chicago 80, Ill. (Jan. '54) *M*

Foster Assocs., Henry Herz, Partner, 88 Chestnut St., Ridgewood, N.J. (Corp. M. Jan. '54) *M*

Gorczyca, Leonard R., Lab. Technician, Div. of Water & Sewers, 827 E. Jefferson St., Phoenix, Ariz. (Jan. '54) *P*

Gray, L. M., Gray Artesian Well Co., Marianna, Fla. (Jan. '54) *R*

Greengard, Charles W., Cons. Engr., 153 Blackhawk Rd., Highland Park, Ill. (Jan. '54) *D*

Grunden, Sven, Operator, Hill Top Estates, Putnam Valley, N.Y. (Jan. '54) *P*

Hallgren, Warren D., Sales Engr., E. N. Hallgren Co., 1252—1st Ave. S., Seattle, Wash. (Jan. '54) *D*

Harris, Leonard J., City Mgr., Wakefield, Mich. (Jan. '54) *MR*

Haskett, James F., Mgr., Fischer & Porter Co., 207 Lux Bldg., 22800 Woodward, Detroit, Mich. (Jan. '54) *P*

Haw, Robert, Water Plant Supervisor, Flint, Mich. (Jan. '54) *P*

Henry, Frank, Plant Chemist, Rochester Gas & Electric Corp., 89 East Ave., Rochester 4, N.Y. (Jan. '54) *P*

Herz, Henry; *see* Foster Assocs.

Higgins, Howard B., Asst. Divisional Sales Mgr., Westvaco Chem. Div., Food Machinery & Chem. Corp., 161 E. 42nd St., New York 17, N.Y. (Jan. '54) *P*

Hillenbrand, Walter A., Owner, Hillenbrand Lumber Co., 3301 Washington Ave., Evansville, Ind. (Jan. '54) *M*

Hinebrook, Vern L., Supt., Water Dept., 30 Gerald Ave., Highland Park, Mich. (Jan. '54)

Hodges, Raymond D., Civ. Engr., East Atlantic Dist., Corps of Engrs., APO 30, Postmaster, New York, N.Y. (Jan. '54) *RPD*

Hodgkinson, Carl F., Dist. Engr., Kansas State Board of Health, Div. of Sanitation, Dodge City, Kan. (Jan. '54) *P*

Holmes, Robert A., Member of Water Board, Webster, N.Y. (Jan. '54) *MD*

Hopewell, Robert P., Chemical Sales, Aluminum Import Corp., 630—5th Ave., New York 20, N.Y. (Jan. '54) *P*

Hoxeng, Raymond B., Research Assoc., U.S. Steel Research & Development Lab., 234 Atwood St., Pittsburgh 13, Pa. (Jan. '54) *PD*

Hungerford & Terry, Inc., A. F. Alling, Vice-Pres. & Gen. Sales Mgr., 226 Atlantic Ave., Clayton, N.J. (Assoc. M. Jan. '54)

Jamison, James T., Field Engr., Harris Pump & Supply Co., Charleston, W.Va. (Jan. '54) *RD*

Johnson, Donald D., Supt., Water & Sewerage Dept., Grayville, Ill. (Jan. '54) *P*

Jones, James G., Chemist & Asst. Engr., Water Dept., Filtration Plant, 601 Taylos St., Lynchburg, Va. (Jan. '54) *MP*

Jones, Richard M., Sales Repr., Southern States Chemical Co., Box B, Branwood Station, Greenville, S.C. (Jan. '54)

Karnis, Arthur L., Water Board, 15996 N.E. 21st Ave., North Miami Beach, Fla. (Jan. '54) *P*

Kennedy, A. P., Mgr., Water Dept., Cooksville, Ont. (Jan. '54)

King, J. D., Supt., Suburban Water Co., 200 Auditorium Circle, San Antonio 5, Tex. (Jan. '54)

King County Water Dist. No. 68, Victor P. Lysell, Supt., Box 487, Bellevue, Wash. (Munic. Sv. Sub. Jan. '54) *MPD*

Knight, Neal W., Hydr. Engr., 3900 Alhambra Circle, Coral Gables, Fla. (Jan. '54)

Koerwitz, Norman A.; *see* Niles (Mich.) Board of Public Works

Koplowitz, Sol, Chief Designing Engr., Havens & Emerson, Rm. 1136, 233 Broadway, New York 7, N.Y. (Jan. '54) *PD*

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(Continued on page 92 P&R)

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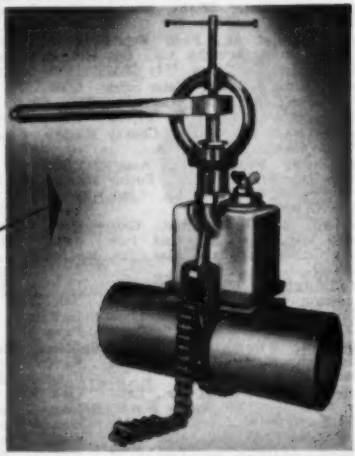

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(*Continued from page 90 P&R*)

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LaFontaine, E. O., Township Engr., Atikokan, Ont. (Jan. '54)

Laine, Gilbert J., Construction Supervisor, Water Works, Evansville, Ind. (Jan. '54) *D*

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Lyons, John J., Mgr., Water Sales Div., Water Dept., 425 Mason St., San Francisco, Calif. (Jan. '54) *M*

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Macdonald, Frank W., Assoc. Prof., Dept. of Civ. Eng., Tulane Univ., New Orleans, La. (Jan. '54) *RPD*

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McCullough, J. Henry, Operator, Anderson Water Works, 303 N. McDuffie St., Anderson, S.C. (Jan. '54)

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Michel, Frederick A., Jr., Eastern Mgr., *Water & Sewage Works,* 155 E. 44th St., New York 17, N.Y. (Jan. '54)

Milhous, Wilbur C., Purchasing Agent, Indianapolis Water Co., 113 Monument Circle, Indianapolis, Ind. (Jan. '54) *M*

Miller, John H. L., Partner, Pacific Water Works Supply Co., 2900—1st Ave. S., Seattle, Wash. (Jan. '54)

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Morgan, George A., Head, Marketing Research Dept., Peoples Gas, Light & Coke Co., 9372 Longwood Dr., Chicago 20, Ill. (Jan. '54) *M*

Morris, R. L., Asst. Supt., Municipal Light & Water System, Leland, Miss. (Jr. M. Jan. '54) *M*

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Niles Board of Public Works, Norman A. Koerwitz, Mgr., 508 E. Main St., Niles, Mich. (Munic. Sv. Sub. Jan. '54)

Nooter, John H.; *see* Nooter Corp.

Nooter Corp., John H. Nooter, 1400 S. 2nd St., St. Louis 4, Mo. (Assoc. M. Jan. '54)

Norwood Corp., J. W. Case, Jr., Mgr., 19150 N.W. 8th Ave., North Miami, Fla. (Corp. M. Jan. '54) *MRP*

Olsen, Carl M., Pres. & Gen. Mgr., Stanwood Water Co., Stanwood, Wash. (Jan. '54) *MD*

Ordway, Edward S., Partner, Havens & Emerson, 233 Broadway, New York 7, N.Y. (Jan. '54) *PD*

Oxford Paper Co., Paul M. Schaffrath, Director of Research, Research Dept., Rumford, Me. (Corp. M. Jan. '54) *MRP*

Palmer, Charlie F., Pres., Tennessee Instrumentation Co., Inc., Box 627, Kingsport, Tenn. (Jan. '54) *P*

Papes, Gordon L., City Supt., Wakeeney, Kan. (Jan. '54) *MRP*

Peterson, William S., Asst. Gen. Mgr. & Chief Engr., Dept. of Water & Power, 207 S. Broadway, Los Angeles 12, Calif. (Jan. '54)

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Rice, Bill, Supt., Buechel Water Dist., Buechel, Ky. (Jan. '54) *D*

Roddy, Charles P., Chief Chemist, Water Dept., Tampa, Fla. (Jan. '54) *P*

Ronhovde, I. N., Chief Instructor, Water & Sewage Training Eng. Extension Service, Texas A & M College, Box 236 F.E., College Station, Tex. (Jan. '54) *MPD*

Rossbach, Joseph J., Jr., Civ. Engr., Metropolitan Utilities Dist., 18th & Harney Sts., Omaha 2, Neb (Jan. '54) *MP*

Schaffrath, Paul M.; *see* Oxford Paper Co.

Schlenz, Harry E., Vice Pres., Pacific Flush Tank Co., 4241 Ravenswood Ave., Chicago 13, Ill. (Jan. '54) *P*

Schulze, Lois J. (Mrs.), Membership Secy., American Water Works Assn., 521—5th Ave., New York 17, N.Y. (Jan. '54)

Selove, Bernard, Counsel, New York Water Service Corp., 132 W. 43rd St., New York 36, N.Y. (Jan. '54) *M*

Self, Herschel O., Supt., Water Supply & Sewage Disposal, Rm. 100, City Hall, Flint, Mich. (Jan. '54) *M*

Sheler, Arthur G., Jr., San. Engr., Nitrogen Div., Ammonia Dept. Development, Allied Chemical & Dye Corp., Hopewell, Va. (Jan. '54) *RPD*

Silliman, Donald W., Water & Sewage Engr., City Hall, Sarnia, Ont. (Jan. '54)

Slaney, Samuel, Branch Mgr., General Chemical Div., Allied Chemical & Dye Corp., 2020 Broadway St., N.E., Minneapolis 13, Minn. (Jan. '54) *P*

Smith, Bert L., Secy., Water Economics Com.—Irrigation Dists. Assn. of California, 932 Pacific Bldg., San Francisco 3, Calif. (Jan. '54) *R*

Smith, Cicero, Supt., Public Works, Forest Grove, Ore. (Jan. '54) *MR*

Smith, Grover H.; *see* Fog-Tite Meter Seal Co.

Snell, M. E., City Engr., Box 507, Grandview, Wash. (Jan. '54) *M*

Solesbee, Willie M., Supt., Water Dept., Greenwood, Ark. (Jan. '54) *P*

Sommers, William J., Acting Gen. Supt., Dept. of Utilities, Fremont, Neb. (Jan. '54) *MD*

South Adams County Water & Sanitation Dist., Arthur E. White, Supt., 6595 E. 70th Ave., Derby, Colo. (Munic. Sv. Sub. Jan. '54)

Spangler, Joseph F., Supt. Pumping & Distr., Water Dept., Wheeling, W.Va. (Jan. '54) *D*

Spencer, Elbert R., Service Engr., D. B. A. Spencer Home Equipment Service, 120 W. Shiawasee St., Lansing 30, Mich.

Svenson, Oscar W., Jr., Mgr., Detroit Sales Office, General Chemical Div., Allied Chemical & Dye Corp., 800 Marion Ave., Piner Rouge, Mich. (Jan. '54) *P*

Swanson, Ingolf C., Lab. Technician, Water Dept., 3610 E. Spring St., Long Beach, Calif. (Jan. '54) *P*

Sweet Home Water Dept., C. E. Ward, Sr., Water Supt., 1140—12th Ave., Sweet Home, Ore. (Corp. M. Jan. '54) *M*

Switzer, George A., Borough Engr., Dept. Water Supply, Gas & Electricity, Borough Hall, Kew Gardens, N.Y. (Jan. '54) *MD*

Taylor, George B., Zone Mgr., Ohio Oil Co., 651 E. Illinois St., Evansville, Ind. (Jan. '54) *D*

Telquist, Frank, Supt., King County Water Dist., No. 79, Box 79, Kenmore, Wash. (Jan. '54) *M*

Templeton, Gerald, Supt. of Water, Otisville, Mich. (Jan. '54)

Thomas, Robert J., Sales Engr., Rockwell Mfg. Co., 122 S. Michigan Ave., Chicago, Ill. (Jan. '54) *M*

Thwaits, Edmond H., Director, Preload Engrs. Inc., 955 N. Monroe St., Arlington, Va. (Jan. '54) *RD*

Turkel, Arnold, Engr. of Design, Div. of Utilities Eng., Dept. of Public Utilities, Cleveland, Ohio (Jan. '54) *M*

Vaughan, R. E.; *see* Vaughan, R. E., Inc.

Vaughan, R. E., Inc., R. E. Vaughan, Pres., 3398 N.W. South River Dr., Miami, Fla. (Assoc. M. Jan. '54)

Wafer, George W., Dist. Engr., Electro Rust-Proofing Corp., 1 Main St., Belleville, N.J. (Jan. '54) *RP*

Walker, Harold C., Chief Accountant, Public Service Com., Box 608, Halifax, N.S. (Jan. '54) *M*

Ward, C. E., Sr.; *see* Sweet Home (Ore.) Water Dept.

Wentworth, Robert R.; *see* Bellflower (Calif.) Water Co.

White, Arthur E.; *see* South Adams County (Colo.) Water & Sanitation Dist.

Whitfield, Allen, Sr. Partner, Whitfield, Selvy, Fillmore & Kelly, 616 Insurance Exchange Bldg., Des Moines 9, Iowa (Jan. '54) *M*

Williams, Karl G., City Mgr., Madison, S.D. (Jan. '54) *MRP*

Williamson, Joe, Jr., Williamson & Assoc., 6731 Manchester Ave., St. Louis 10, Mo. (Jan. '54)

Windt, Paul G., Gen. Supt., New York Water Service Corp., 915 Beach Ave., Rochester 12, N.Y. (Jan. '54) *PD*

Wolfe, Thomas F., Jr., Salesman, Eddy Valve Co., 140 Cedar St., New York 6, N.Y. (Jan. '54) *D*

Zwickle, Andrew B., Vice Chairman, Northampton Borough Municipal Authority, 1717 Main St., Northampton, Pa. (Jan. '54) *M*

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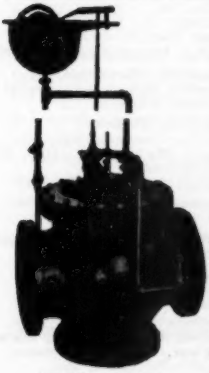

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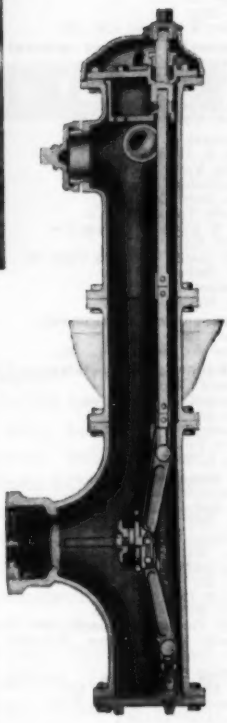

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Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Chain Belt Co.
Infilco Inc.
Walker Process Equipment, Inc.

Ozonation Equipment:
Welsbach Corp., Ozone Processes Div.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Crane Co.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
James B. Clow & Sons
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
Southern Pipe & Casing Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Koppers Co., Inc.
Pipelife, Inc.
Reilly Tar & Chemical Corp.
Southern Pipe & Casing Co.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.
Universal Concrete Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pipe, Plastic:
Carlon Products Corp.

Pipe, Steel:
American Locomotive Co.
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.
Southern Pipe & Casing Co.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Morse Bros. Mchy. Co.

Pumps, Chemical Feed:
Infilco Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.

Pumps, Diaphragm:
Dorr Co.
Morse Bros. Mchy. Co.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

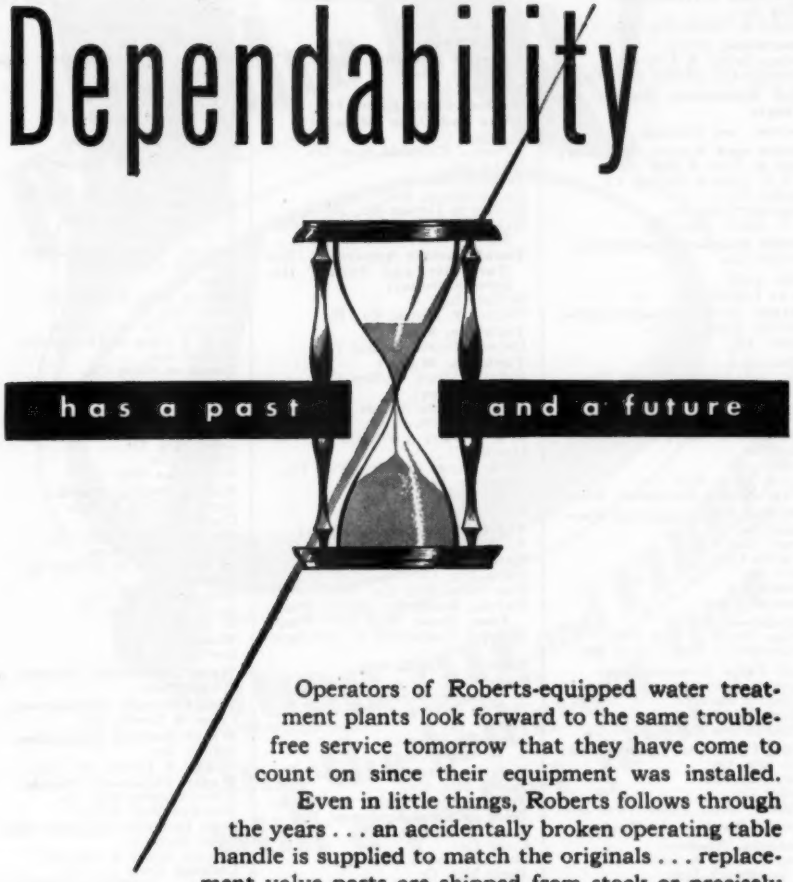
Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Economy Pumps, Inc.

Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.

Dependability



Operators of Roberts-equipped water treatment plants look forward to the same trouble-free service tomorrow that they have come to count on since their equipment was installed. Even in little things, Roberts follows through the years . . . an accidentally broken operating table handle is supplied to match the originals . . . replacement valve parts are shipped from stock or precisely made to the original pattern. Modernization of design has never obsoleted any Roberts equipment.

There has not been, or will there be, an "orphan" with the name Roberts attached. Integrity is built into every piece of Roberts equipment . . . for the years.

Roberts Filter . . . Nameplate of dependability

ROBERTS FILTER
Manufacturing Co.
Darby, Penna.

MECHANICAL EQUIPMENT
BY
ROBERTS FILTER MFG. CO.
DARBY, PENNA.

Recording Instruments:
Infilco Inc.
Wallace & Tiernan Co., Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves; see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Permutit Co.

Soda Ash:
Solvay Process Div.

Sodium Hexametaphosphate:
Blockson Chemical Co.
Calgon, Inc.

Softeners:
Belco Industrial Equipment Div.
Cochrane Corp.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Cochrane Corp.
Infilco Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
American Locomotive Co.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
James Jones Co.
Mueller Co.
Welsbach Corp., Kitson Valve Div.

Storage Tanks; see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
Johnson, Edward E., Inc.
R. D. Wood Co.

Surface Wash Equipment:
Cochrane Corp.
Permutit Co.

Swimming Pool Sterilization:
Everson Mfg. Corp.
Omega Machine Co. (Div., B-I-F Industries)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
American Locomotive Co.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
A. P. Smith Mfg. Co.
Hays Mfg. Co.
Mueller Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.
Welsbach Corp., Kitson Valve Div.

Taste and Odor Removal:
Cochrane Corp.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve-Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Davis Mfg. Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Backflow Engineering & Equipment Co.
James B. Clow & Sons
Crane Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Belco Industrial Equipment Div.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Davis Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Davis Mfg. Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Davis Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Davis Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Crane Co.
Davis Mfg. Co.
Mueller Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Well Drilling Contractors:
Layne & Bowler, Inc.

Well Screens
Johnson, Edward E., Inc.

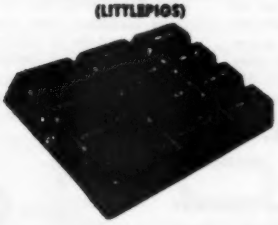
Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

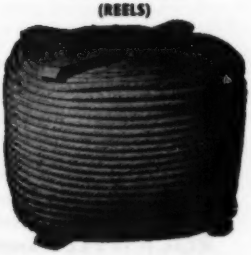
A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1953 AWWA Directory.

HYDRO-TITE
(POWDER)

HYDRO-TITE
(LITTLEPIGS)

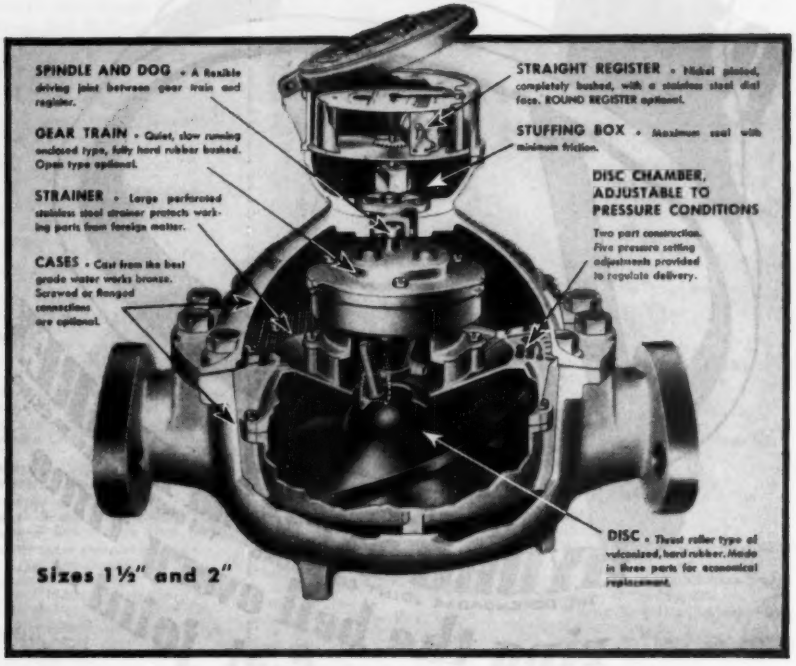


FIBREX
(REELS)



HYDRAULIC DEVELOPMENT CORPORATION

INSIDE INFORMATION about Rockwell Type 6 Disc Meters


SPINDLE AND DOG • A flexible driving joint between gear train and register.
GEAR TRAIN • Quiet, slow running enclosed type, fully hard rubber bushed. Open type optional.
STRAINER • Large perforated stainless steel strainer protects working parts from foreign matter.
CASES • Cast from the best grade water works bronze. Screwed or flanged connections are optional.
STRAIGHT REGISTER • Nickel plated, completely bushed, with a stainless steel dial face. ROUND REGISTER optional.
STUFFING BOX • Maximum seal with minimum friction.
DISC CHAMBER, ADJUSTABLE TO PRESSURE CONDITIONS
Two part construction. Five pressure setting adjustments provided to regulate delivery.
DISC • Thrust roller type of vulcanized, hard rubber. Made in three parts for economical replacement.
Sizes 1½" and 2"

These Quality Features Mean —

GREATER ACCURACY, LONGER METER LIFE

For measurement accuracy that lasts on all your 1½" and 2" services, you can make no better choice than the Rockwell Type 6 meter. In it, you'll get every wanted feature and many extras including a measuring chamber that can be adjusted to five different positions to regulate delivery. This prolongs meter life by governing maximum allowable rate of flow in accordance with the line pressure, and prevents excessive wear due to over-speeding.

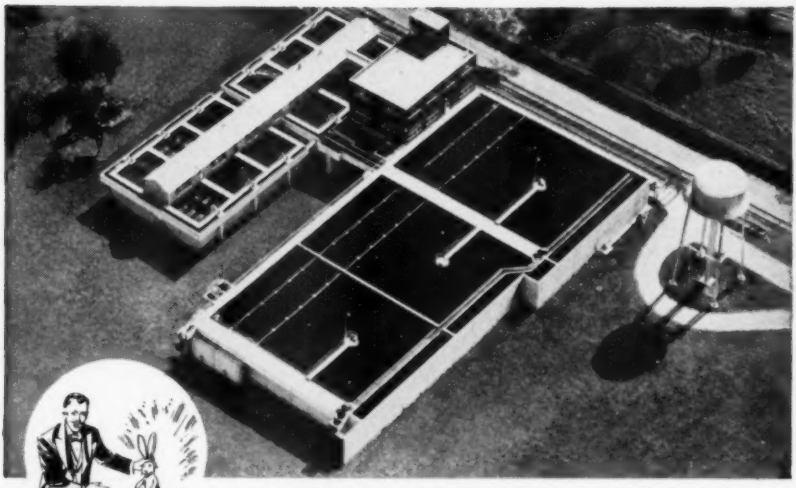
To get all the revenue from profitable commercial and small industrial services, invest now in Rockwell Type 6 meters. They will repay their cost many times through a superior degree of maintained accuracy and lowered repair costs.

ROCKWELL MANUFACTURING COMPANY

PITTSBURGH 8, PA. Atlanta Boston Chicago Houston
Los Angeles N. Kansas City New York Philadelphia
Pittsburgh San Francisco Seattle Tulsa

In Canada: Peacock Brothers Limited

The Symbol for Service, Quality and Performance in Water Meters



There's No "Magic Formula"

Every water treatment problem is different

No two water treatment problems are exactly alike. To get the best — and most economical — answer to your specific problem requires careful analysis of raw water composition, rate of flow and the results you require.

There *is* no magic formula . . . no single equipment unit that will give ideal results under all conditions. That's why it will pay you to check both conventional and high-rate units on every water treatment problem.

For a brief picture of the complete Dorr equipment line ask for Bulletin #9141. The Dorr Company, Stamford, Conn.

Repeat order in 1950 "proves out" a "conventional" installation made in 1948.

Quick facts about the Dorrco installation at the
Hollingsworth & Whitney Co., Chickasaw Mills, Mobile, Alabama

1948 . . . First order installed with a design capacity of 10 MGD: 2 Dorrco Flash Mixers, 1 Dorrco Flocculator, 1 Dorrco Squarex Clarifier, 85' square.

Operating Results . . . Raw water: Color — 65-70 ppm, Raw water: Turbidity — 3.5-3.9 ppm, Finished water: Color — 3 ppm (Dosage in ppm: Alum 20, Soda Ash 15, Chlorine 3 to 5)

1950 . . . Second order installed with design capacity of 16 MGD (Total design capacity: 26 MGD): 1 Dorrco Flash Mixer, 2 Dorrco Flocculators, 2 Dorrco Squarex Clarifiers, 75' square.

Flocculator and Squarex are trademarks of THE DORR COMPANY — Reg. U. S. Pat. Off.

Every day, nearly 8 billion gallons of water are treated by DORR equipment.

Better tools TODAY to meet tomorrow's demand

DORRCO

DORR

WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT

THE DORR COMPANY • ENGINEERS • STAMFORD, CONN.

Offices, Associated Companies or Representatives in principal cities of the world.

LEADITE

Trade Mark Registered U. S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY

Girard Trust Co. Bldg. Philadelphia, Pa.